CLOUD GAMING: PLAY THE LATEST GAMES WITHOUT EXPENSIVE GEAR

CUSTOM PC

THE BEST-SELLING MAG FOR PC HARDW[illegible]CKING, GAMING & MODDING / ISSUE 183

NVIDIA RETURNS

CINEMA-QUALITY EFFECTS COME TO GAMES

GEFORCE RTX 2080 & 2080 Ti REVIEWED

DEEP LEARNING FOR GRAPHICS

INSIDE THE NEW GPUs

PLUS: REAL-TIME RAY TRACING EXPLAINED

PLUS: LIQUID COOLERS GROUP TEST

9 771740 744059 12
DECEMBER 2018 / £5.99

ALSO IN THIS ISSUE

COOLER MASTER'S £430 CASE p28 / GIGABYTE AORUS RGB MEMORY p19 / SAMSUNG PORTABLE NVME SSD p32
INSIDE FROZEN SYNAPSE 2 p81 / GIGABYTE B450 MINI-ITX MOTHERBOARD p26 / TWO POINT HOSPITAL p76
WATER-COOLING AMD'S 32-CORE THREADRIPPER p102 / HOW TO FIT MOTHERBOARD MONOBLOCKS p106

Easy to learn, easy to master.

The new generation provides the perfect case for silence enthusiasts and those who want to master their PC build in the most convenient way. Silent Base case series makes it unbelievably easy to set up your new system, almost like a puzzle with just four pieces. Well-elaborated features like noise dampening vents, 10mm thick insulation mats and the convenient PSU shroud support the fast and simple installation of your whisper-quiet PC build.

SILENT BASE 801

- Three pre-installed Pure Wings 2 140mm fans
- Fan controller for up to six fans with PWM hub option
- Support of water cooling radiators up to 420mm length
- Offers space for eleven SSDs or five HDDs out of the box
- Invertible motherboard layout

SILENT BASE 601

- Two pre-installed Pure Wings 2 140mm fans
- Fan controller for up to three fans
- Support of water cooling radiators up to 360mm length
- Offers space for six SSDs or three HDDs out of the box

GERMANY'S NO. 1* PSU MANUFACTURER

*GfK data 2018

For more information visit **bequiet.com**

Available at: scan.co.uk · overclockers.co.uk · ebuyer.com · novatech.co.uk aria.co.uk · cclonline.com · amazon.co.uk

be quiet!®

Welcome

Custom PC Issue 183

Editorial
EDITOR
Ben Hardwidge
editor@custompcmag.org.uk

MODDING EDITOR
Antony Leather

GAMES EDITOR
Rick Lane

ART EDITOR
Bill Bagnall
www.billbagnalldesign.com

PRODUCTION EDITOR
Julie Birrell

CONTRIBUTORS
Christopher Minasians, Gareth Halfacree, Gareth Ogden, James Gorbold, Mike Jennings, Phil Hartup, Richard Swinburne, Tim Danton, Tracy King

PHOTOGRAPHY
Antony Leather, Gareth Halfacree, Mike Jennings

Publishing & Marketing
PUBLISHER
Simon Brew
simonbrew@hotmail.com

LICENSING MANAGER
Carlotta Serantoni
Carlotta_Serantoni@dennis.co.uk
+44 (0)20 3890 3840

LICENSING & SYNDICATION ASSISTANT
Nicole Adams
Nicole_Adams@dennis.co.uk
+44 (0)20 3890 3998

SYNDICATION MANAGER
Ryan Chambers
+44 (0)20 3890 4027

Commercial & Advertising
Ashley Wood
ashley_wood@dennis.co.uk

The paper used in this magazine is produced from sustainable fibre, manufactured by mills with a valid chain of custody.

Dennis Publishing Limited
Tel: 020 3890 3890

DIRECTOR OF ADVERTISING
Julian Lloyd Evans

MANAGING DIRECTOR DENNIS TECHNOLOGY
John Garewal

NEWSTRADE DIRECTOR
David Barker

FINANCE DIRECTOR
Brett Reynolds

CHIEF EXECUTIVE
James Tye

COMPANY FOUNDER
Felix Dennis

Subscriptions
You can manage your existing subscription through **http://ManageMyMags.co.uk** – this should be your first port of call if you have any queries about your subscription.
Email: subscriptions@custompc.co.uk

Annual subs: UK £44.99
UK subs: 0330 333 9493
Overseas subs:
Europe £65, ROW £85
Overseas subs: +44 (0)1795 592 906

LOGOS AND REPRINTS
Ryan Chambers
Ryan_Chambers@dennis.co.uk
020 3890 4027

Printed by William Gibbons

Distributed by Seymour Distribution
020 7429 4001

OVERSEAS NEWSSTAND
Geraldine Grobler, Seymour International Ltd . +44 (0)20 7429 4066

Custom PC is produced by Mr Freelance Limited and published monthly by Dennis Publishing Ltd, 31-32 Alfred Place, London WC1E 7DP, a company registered in England number 1138891.

Contents

Welcome to Issue 183

COVER STORY P20

20 The Turing test
Real-time ray tracing, deep learning for games and stratospheric prices. Nvidia's first new gaming GPU architecture for years has raised a few eyebrows with is final arrival, and it's an absolute monster. In this issue, we delve into the new GeForce RTX 2080-series GPUs to see what makes them tick. We've also put them through their paces in several gruelling game tests and tried out as many of their new features as possible.

There's a lot to digest here, from the massive architectural overhaul to the question marks over the future of ray tracing in games. It's for this reason that we've dedicated several pages not just to reviewing the new GPUs, but also to discussing real-time ray tracing in a full feature on p84.

Highlights

10 The cost of ray tracing
Richard Swinburne asks if Nvidia is right to commit so much silicon to what are currently niche features.

12 Total War: Playground
Tracy King discusses the current furore around putting female characters in war games.

28 Cooler Master's £430 case
We look at the Cosmos C700M to see if it can justify its asking price.

46 Liquid coolers
We put eight 240mm all-in-one liquid coolers through their paces on Intel and AMD CPU sockets.

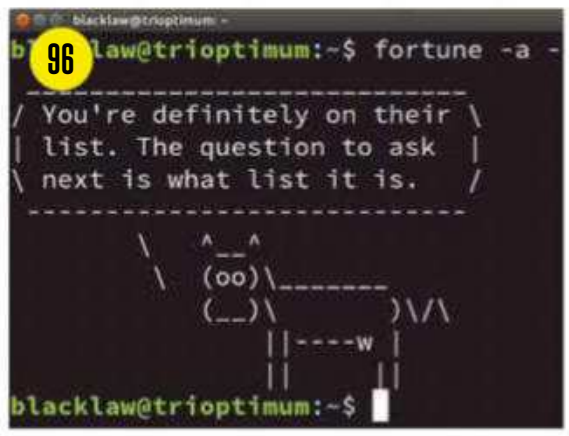
76 Two Point Hospital
Rick Lane enthuses about the latest hospital sim, which picks up where Theme Hospital left off.

84 Real-time ray tracing
With its realistic lighting, will ray tracing really be the future of gaming, and how exactly is Nvidia managing to do it in real time? Find out in this dedicated feature.

90 Cloud gaming
Play the latest PC games without forking out for expensive hardware. After the fall of OnLive, Rick Lane investigates the current cloud gaming options.

96 Hobby tech
Gareth Halfacree makes a daily schedule printer, tries out the high-tech MiniWare TS100 soldering iron and reviews new programming-themed game Exapunks.

104 How to guides
Antony Leather shows you how to control your fans and pumps effectively, and install a water-cooling monoblock on your motherboard.



Regulars

8 From the editor
10 Richard Swinburne
12 Tracy King
14 Incoming
18 Letters
38 Custom kit
42 How we test
64 Elite products
75 Inverse look
96 Hobby tech
101 For the win!
102 Customised PC
104 How to guides
109 Top tools
110 Readers' drives
114 James Gorbold

Cover guide

Reviewed this month

32 PRODUCTS REVIEWED

Reviews

MEMORY
19 Gigabyte Aorus RGB Memory

GRAPHICS CARDS
20 Nvidia GeForce RTX 2080 Founders Edition
20 Zotac GeForce RTX 2080 Ti AMP!

MOTHERBOARD
26 Gigabyte B450 I Aorus Pro WiFi

CASES
28 Cooler Master Cosmos C700M
30 Thermaltake Level 20 VT

SOLID STATE DRIVE
32 Samsung Portable SSD X5 1TB

MONITORS
34 ViewSonic VP3268-4K
36 MSI Optix MPG27C

Custom kit

38 Pocket Spinner Multi-tool
38 KKmoon Delux T9
38 Dodow Sleep Light
39 Sphero Mini
39 iWalk Power Bank 12,000mAh
39 Nenrent Wireless Earbud

240mm all-in-one liquid cooler Labs

47 Alphacool Eisbaer LT 240
48 Cooler Master MasterLiquid ML240R RGB
50 Corsair H100i RGB Pro
51 Deepcool Castle 240
52 EK Water Blocks Phoenix 240
53 Fractal Design Celsius 24
54 Game Max Iceberg 240mm
55 NZXT Kraken X52

PC system reviews

58 Scan 3XS Vengeance RTX Ti
60 Wired2Fire Diablo RTX
62 Chillblast Fusion Juggernaut 2080

Games

76 Two Point Hospital
78 Phantom Doctrine
78 We Happy Few
80 Graveyard Keeper

Hobby tech

98 MiniWare TS100 soldering iron
100 Exapunks

Windows 10

CyberPowerPC recommends Windows.
One experience for everything in your life.

FROM **£2399**

Liquid Cooling Included

Infinity Xtreme Titanium

Windows 10 Home

Intel® Core™ i7-7820X Processor
NVIDIA GeForce MSI GTX 1080Ti 11GB Video Card
ASUS TUF X299 MK 2 Mainboard
32GB DDR4 3200mhz Corsair Vengeance LPX Memory
250GB Samsung 970 EVO SSD
1TB Seagate Firecuda SSHD
Cooler Master HAF H500P Gaming Case
Corsair 600W Power Supply
Corsair H100i V2 Cooling System w/ 2xMF120R Fans
TP-Link Archer T6E Dual Band Wireless Card

HD 7.1 | Optional | Optional

FROM **£1499**

Liquid Cooling Included

Infinity X88 Pro

Windows 10 Home

Intel® Core™ i7-8700K Processor
NVIDIA GeForce MSI GTX 1070Ti 8GB Video Card
ASUS PRIME Z370-P Mainboard
16GB DDR4 2400mhz Corsair Vengeance LPX Memory
250GB Samsung 860 EVO SSD
2TB Seagate SATA-III 64MB Cache HDD
Syber M Gaming Case
Cooler Master 600W Power Supply
Cooler Master MasterLiquid 120 Cooling System
Pro Overclocking

HD 7.1 | Optional | Optional

FROM **£949**

Liquid Cooling Included

Infinity X66

Windows 10 Home

Intel® Core™ i5-8600K Processor
NVIDIA GeForce MSI GTX 1060 3GB Video Card
MSI Z370-A PRO Mainboard
8GB DDR4 2400mhz Corsair Vengeance LPX Memory
2TB Seagate SATA-III 64MB Cache HDD
Cooler Master Masterbox MB500 Gaming Case
Cooler Master 400W Power Supply
Corsair Hydro Series H60 Cooling System

HD 7.1 | Optional | Optional

FROM **£1299**

Liquid Cooling Included

Infinity X66 Pro

Windows 10 Home

Intel® Core™ i5-8600K Processor
NVIDIA GeForce MSI GTX 1070 8GB Video Card
MSI Z370-A PRO Mainboard
16GB DDR4 2400mhz Corsair Vengeance LPX Memory
240GB Kingston A400 2.5" SSD
2TB Seagate SATA-III 64MB Cache HDD
INWIN 101 MID TOWER Gaming Case
Cooler Master 600W Power Supply
Corsair Hydro series H60 Cooling System
Extreme Overclocking

HD 7.1 | Optional | Optional

FROM **£649**

Infinity X44

Windows 10 Home

Intel® Core™ i3-8100 Processor
NVIDIA GeForce MSI GTX 1050Ti 4GB Video Card
Asus Prime H310M-K Mainboard
8GB DDR4 2400mhz Corsair Vengeance LPX Memory
1TB Seagate SATA-III HDD
Cooler Master MASTERBOX LITE 5 Tower Case
Thermaltake 350W Power Supply
Cooler Master MA410P RGB Cooler

HD 7.1 | Optional | Optional

15.6"HD

FROM **£1099**

Tracer III 15 VR GT

Windows 10 Home

Intel® Core™ i7-8750H Processor
HM370 Chipset
NVIDIA GeForce GTX 1060 6GB Video Card
16GB DDR4/2400mhz SODIMM Memory
120GB WD Green M.2 SATA-III SSD
1TB Seagate BarraCuda SATA-III Hard Drive
15.6" FHD IPS 1920 X 1080 Display
Build in HD Audio Realtek ALC269Q
Intel® Dual Band Wireless-AC 9560 802.11ac

5.5 hrs | Bluetooth 5 | 2x USB 3.1 2x USB 2.0

1x USB type C	Built-in 720P HD Webcam	2.8 kg	AC WiFi

ORDER TODAY! **03333 237 776**

Work easy. Play hard. Windows

BEN HARDWIDGE / FROM THE EDITOR

COMPETITIVE PLAY

Ben Hardwidge laments the state of competition in the GPU industry, but a new hope is potentially on the horizon

Now would usually be a golden moment to scoop up a graphics card bargain, with the arrival of brand-new GPUs sending the prices of the old guard tumbling down as retailers try to shift their old stock. Not this time. GeForce GTX 1080 Ti cards are a little cheaper than previously, but they're still demanding at least £650 inc VAT. It's hardly a bargain.

This time, there simply hasn't been a like-for-like swap. Nvidia's new RTX 2080 and 2080 Ti cards are demanding huge premiums, meaning the older GPUs can still happily chug along at or near their old prices.

There are many factors at play here, and Richard Swinburne has covered the cost of the new features, and whether they're worth it, on p10. What I want to discuss here is the sorry state of competition in the current GPU business.

We saw a similar situation in the CPU industry for several years. As James Gorbold discusses on p114, Intel's current stock shortage means its CPU prices are shooting up again, but it doesn't matter now because we have decent competition – unless you *really* want the highest clock speeds possible, you can pick up a highly competitive AMD Ryzen CPU (with two more cores) for much less money.

That wasn't the case for a long time, though, when AMD's uncompetitive CPU architecture enabled Intel to keep churning out depressingly similar quad-core CPUs year after year at whatever price it liked.

That's the benefit of competition, and it may as well not exist in the current GPU arena. AMD's Radeon RX Vega GPUs were delayed, overpriced and underwhelming, and their prices were also affected by a major supply shortage when the currency mining craze peaked. They're simply not competitive as gaming GPUs.

There are rumours about new AMD GPUs turning up soon, with a move to 7nm transistors. However, given the lateness and uncompetitive performance of the first Vega chips, and the huge amount of resources that Nvidia has clearly poured into developing Turing, AMD will really have its work cut out to make a product that can knock the RTX 2080 Ti for six. I'll be surprised if AMD is even aiming that high now.

Curiously, though, there is potentially some other competition for Nvidia's RTX GPUs in the works, not from AMD, but from Intel. The CPU maker has been nabbing graphics staff from AMD left, right and centre over the past year, and has already announced plans to launch a discrete GPU as soon as 2020. Intel also has a wealth of experience in ray tracing, not just for render stations, but for gaming too. It quickly hired real-time ray-tracing guru Daniel Pohl in 2008 after seeing his own efforts with the Quake engine, and Pohl is now a computer vision engineer at the firm. Many years ago, Intel even had a graphics card based on CPU cores for real-time ray tracing in the works.

> With its knowledge of ray tracing, it's possible we could see a very different GPU emerge from Intel

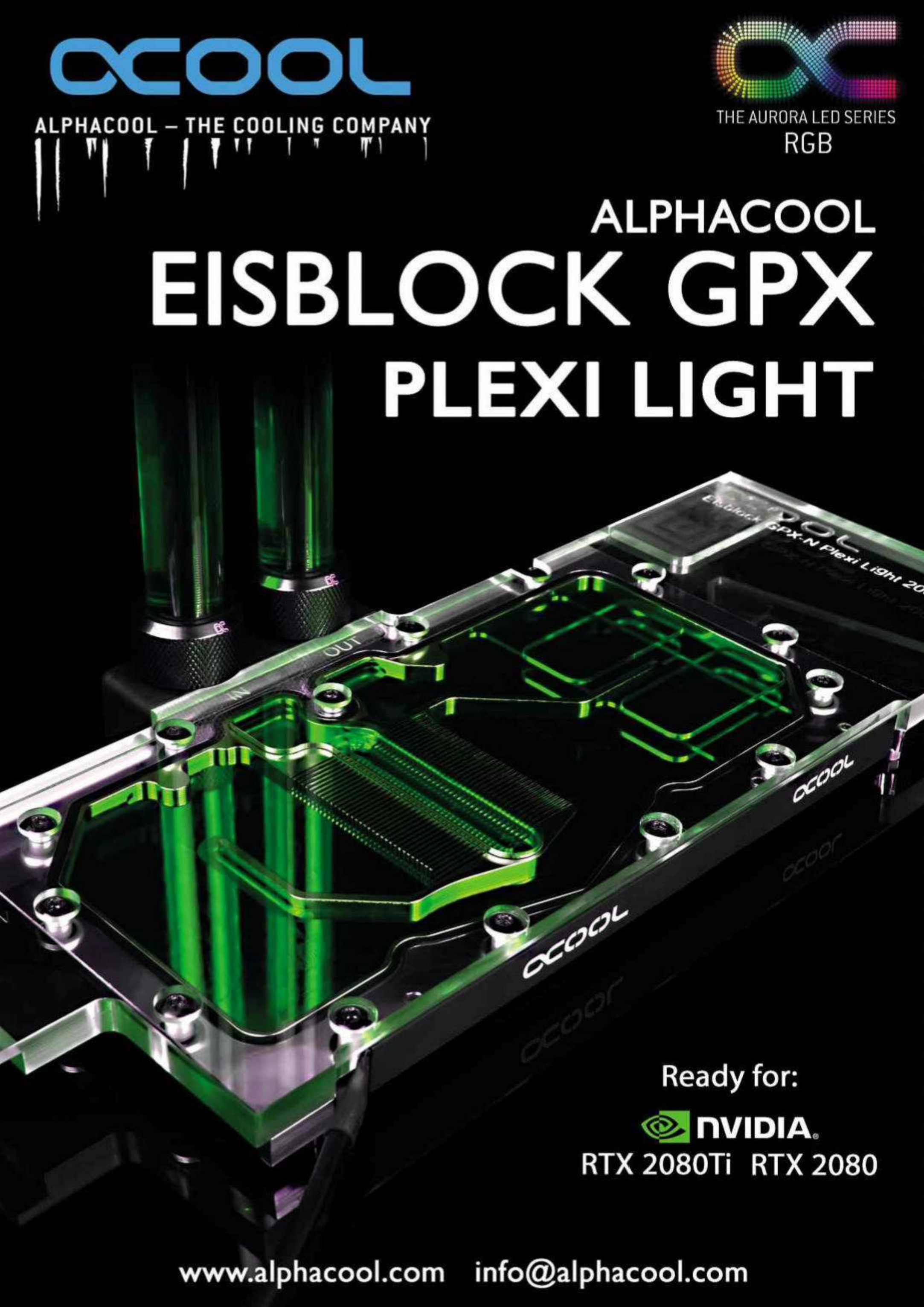
With its knowledge of ray tracing, and its expertise gained from nabbing AMD's staff, it's quite possible we could see a very different GPU emerge from Intel – one that might not match Nvidia's rasterisation performance, but may beat it in real-time ray tracing – it may even manage both. The challenge for Intel, as always with its graphics, will be providing adequate game support and driver updates, but we sorely need competition in the GPU business now, and Intel could potentially offer it, especially if games do indeed shift towards using ray tracing in games. CPC

Ben Hardwidge is the editor of Custom PC. He likes PCs, heavy metal, real ale and Adeptus Titanicus. editor@custompcmag.org.uk @custompcmag

ALPHACOOL – THE COOLING COMPANY

THE AURORA LED SERIES
RGB

ALPHACOOL
EISBLOCK GPX
PLEXI LIGHT



Ready for:

NVIDIA
RTX 2080Ti RTX 2080

www.alphacool.com info@alphacool.com

RICHARD SWINBURNE / VIEW FROM TAIWAN

THE COST OF RAY TRACING

Richard Swinburne asks if Nvidia is right to commit so much silicon to what are currently niche features

For me, the biggest news about Nvidia's new RTX GPUs isn't, in fact, the performance, but the astronomical prices. After two and a half years of GTX 1000-series GPUs, the leap in prices for the new RTX cards has left a lot of potential upgraders unhappy. However, let's be pragmatic about the market situation, as there's no whiff of high-end competition from AMD, and Nvidia is in business to make money. Also, looking deep into the new Turing architecture, it's clear the new chips also cost significantly more to make, and the research and development costs will have been considerable as well.

The GTX 1080 Ti (GP102) core offered 471mm² of silicon, the GTX 1080 and GTX 1070 (GP104) were 341mm² and the GTX 1060 and GTX 1050 (GP106) were 200mm². However, in this generation, the sizes of the RTX 2080 Ti (TU102), RTX 2080 (TU104) and RTX 2070 (TU106) silicon are *huge,* at 754mm², 545mm² and 445mm² respectively. Even 'low-end' TU106 silicon is almost the same size as last generation's premium GPUs – Nvidia's GTX 1080 Ti and AMD's Vega64 (486mm²). Adding several billion transistors to each new series means the cost to make them has increased significantly.

This extra space isn't substantially occupied by more stream processors, but by the new Tensor (AI) Cores and RT (ray tracing) hardware embedded into each GPU alongside the traditional rasterising kit. Since AI and ray tracing aren't currently actively used in games, Nvidia has taken a 'build it and they will come' approach. But even with its current market dominance, it's going to be a difficult journey. Without any relevance to the millions of existing games, it's a large cost pushed onto the consumer that affords little obvious benefit in the near future.

> Nvidia has taken a 'build it and they will come' approach

The Tensor (AI) Cores are being put to use in a fancy new anti-aliasing mode, which does appear to improve performance, but there are already lots of AA options in games, so it's hardly a must-buy feature. Meanwhile, AI may be having a transformative effect on virtually every other compute-related industry, including cars, cameras and smartphones, but the PC has largely been left out.

Of course, ray tracing can clearly produce much more realistic lighting than rasterisation – we've known that for at least two decades – but it requires such high performance, as well as dedicated hardware, that it's an enormous mountain to climb. Game developers need a sufficiently large, established ecosystem of ray tracing-capable cards already in people's PCs to push them to embrace it. This year we've already seen what happens in VR when the high cost and lack of demand means low economic incentive for developers.

In my opinion, Nvidia had two alternatives it should have considered. Firstly, a dedicated add-in card that people could buy to partner with their brand-new (rasterisation-only) graphics card, a bit like the original 3D graphics and PhysX accelerators.

If a separate card wasn't possible, then a chiplet approach could have offered consumer choice. 'Chiplet' is a new term that describes putting many little chips together side by side and working as if they were a single monolithic unit. Nvidia could possibly have separated its RT and Tensor Cores into a chiplet and offered consumers a with or without choice for its new graphics cards.

I certainly hope ray tracing gets its day in the sun (ahem), but at this price I'm happy to rasterise for a while longer. CPC

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

iiyama G-MASTER
MONITORS 4 GAMERS

UNLOCK YOUR GAME

gmaster.iiyama.com

JOIN THE PRO SQUAD

1ms
144Hz
Free Sync

RED EAGLE™

GB2488HSU | GB2788HS | GB2760QSU

GET IN THE GAME

1ms
Free Sync

BLACK HAWK™

GE2288HS | G2530HSU | G2730HSU

IMMERSE YOURSELF IN THE GAME

CURVED
Free Sync

GOLD PHOENIX™

GB2888UHSU | G3266HS

ENTER A NEW DIMENSION

2560 x 1440
1ms
Free Sync

SILVER CROW™

GB2783QSU

TRACY KING / SCEPTICAL ANALYSIS

TOTAL WAR: PLAYGROUND

Tracy King discusses the fury around putting female characters in war games

'Who wants to play ... Aaaarmy,' we'd chant, linking arms and marching around the school playground at lunchtime. 'No boys! Just girls!' We were eight years old and had recently noticed that the boys were playing Army but excluding girls. It was annoying because Army was an extremely fun game in which you ran around making machine gun noises and diving behind imaginary bunkers. We fought back by starting our own, girl-only game of Army.

Why did the little boys choose to exclude the girls in their war game? Eight-year-olds aren't usually sticklers for historical accuracy, but although we had learned about the World Wars in class, we weren't taught that it was actually illegal for women to serve in frontline combat units, and that many thousands of women did in fact serve in WWII, including my own grandmother, who operated a massive gun and shot down Nazi planes.

> My own grandmother operated a massive gun and shot down Nazi planes

Women from all countries served and even died in service, but you won't find their existence and sacrifice in the history books. Historical accuracy is in the eye of those who know history.

Today, around 20 per cent of active service personnel are female. It's a weird bit of equality, the right to fight and die in a war, but we're not here to discuss the merits of pacifism. We're here to discuss video games. In May this year, there was a big war over EA DICE's Battlefield V, which had the audacity to feature women in its trailer.

The protest hashtag #notmybattlefield was born. Pre-orders for Battlefield V have been pretty dire, and the release delayed, but there's no evidence that it's a direct result of letting women into the combat man cave (it might be because of negative PR around EA DICE's Star Wars Battlefront II, which suffered from heavy media criticism for its microtransactions, leading to 'review bombing' on Metacritic).

But regardless of what's leading poor sales, EA's chief creative officer Patrick Söderlund isn't going to let the 'no girls, just boys' campaigners get their way, responding to criticism about historical accuracy in Battlefield V by saying, 'Either accept it or don't buy the game.'

Recently, similar complaints gained attention when 350 new negative reviews appeared of Creative Assembly's Total War: Rome II, which features female generals in an ancient setting. The female generals hadn't been a problem for the entirety of the game's release, until someone posted a screenshot purporting to show that the game had given him an all-female line-up, and it escalated from there.

The chances of getting just one female general in Total War: Rome II is small. A statement from CA says there's a 10-15 per cent chance of women appearing as recruitable generals for some of the playable factions. 'The exceptions are the Greek states, Rome, Carthage and some Eastern factions, which have a 0 per cent chance, and Kush, which has a 50 per cent chance," it says.

It's difficult to understand why anyone would have a problem with that, but some gamers are complaining that they're not objecting to the presence of women in their game – it's the 'take it or leave it' attitude of the developers. I'm not really sure what other approach developers can take though. They're not going to stop putting women in games, even if it throws military history out of the window, because women buy and play games too, and we have every right to play as ourselves. After all, male gamers are complaining that they don't want to play as the opposite sex. Me too, dudes, me too. CPC

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

CREATIVE®

“ Whether I was playing games, watching videos, or listening to music, one word kept coming out of my mouth, and that was “wow.” Everything sounds great on this card, and you can immediately and easily hear the difference between the AE-5 and onboard audio. It’s like lifting your head out from underwater. ”

- unlocked.newegg.com

SOUND BLASTER X AE-5®

CES INNOVATION AWARDS 2018 HONOREE

WINNER OF
Computer Hardware & Components / Computer Accessories

HI-RESOLUTION PCIE GAMING SOUND CARD AND DAC WITH RGB AURORA LIGHTING SYSTEM

Get the ultimate audio performance with a 122dB 32-bit/384kHz DAC featuring premium audiophile components and a proprietary 600Ω discrete headphone amp for true lossless sound. Experience rich, immersive audio in games, music, movies and more. Be in unique control of every audio enhancement and lighting effect now in your PC case.

122dB DAC | Hi-Res 32bit/384kHz | DISCRETE 5.1 SURROUND | VIRTUAL 7.1 SURROUND | BLASTERX ACOUSTIC ENGINE | CRYSTAL VOICE | Powered by Sound CORE3D

AURORA REACTIVE

16.8 MILLION REACTIVE COLORS

creative.com

Incoming

We take a look at the latest newly announced products

Oculus unveils standalone Quest headset

Oculus has announced a new member of its VR headset line-up, promising to completely do away with the need for a wired connection, or even a PC. The new Quest bundle features two Touch wireless controllers, as well as a headset packed with dedicated hardware, freeing the wearer from constraints. Meanwhile, each eye will get a dedicated 1,600 x 1,440 screen, and 64GB of storage space will be provided. There's no advanced detail on the specs available at the time of going to press, but Oculus says the Quest will be released in 2019 at a price of $399 US (around £366 inc VAT).

GeForce RTX 2070 inbound

Nvidia isn't wasting any time getting its Turing cards out the door, with the cheaper RTX 2070 quickly following the heels of the RTX 2080 and 2080 Ti (see p20). Based on Nvidia's smaller TU106 GPU, the RTX 2070 will have all of its parts enabled (unlike the 2080 chips), with 2,304 stream processors and 8GB of GDDR6 memory clocked at 7000MHz (14000MHz effective).

As with the 2080, there will be Nvidia Founders Edition cards, plus third-party cards, with UK pricing set at a £569 inc VAT for the latter from **www.nvidia.com**. That's a fair bit cheaper than the 2080-series cards, but still a lot of money compared with previous-generation GPUs. The GeForce RTX 2070 will be available to order on 17 October, 2018.

Intel readies mainstream 8-core CPUs

Despite its current stock shortage woes (see p114), Intel is planning to launch a new range of 9000-series CPUs before the end of the year. Most notably, the Core i9-9900K and Core i7-9700K will bring 8-core CPUs to the mainstream LGA1151 platform, along with a slightly revised Z390 chipset.

What's more, Intel has also listened to enthusiasts this time, and is swapping the thermal paste under the Core i9-9900K's heatspreader for a proper soldered connection, which should make for better cooling and maybe better overclocking.

According to our sources, the Core i9-9900K will have a 3.6GHz base clock, but the ability to boost all its cores to 4.7GHz and a single core to 5GHz. It will also support Hyper-Threading for a total of 16 threads, unlike the 8-core 9700K, which will only have eight threads.

There's no word on pricing at the time of going to press, but we hope to have a full review in the next issue.

Enermax launches RGB TR4 coolers

Enermax has launched a trio of all-in-one liquid coolers designed to tame the heat from AMD's massive Threadripper CPUs, while also sporting RGB lighting. Featuring a custom coldplate that covers the whole TR4 heatspreader, the LiqTech TR4 II coolers come in 240mm, 280mm and 360mm flavours. Each cooler uses high-pressure fans and an efficient EF1 pump, and Enermax claims they can deal with processor TDPs over 500W, meaning they could even happily cool a 32-core Threadripper 2990WX. Unlike the first LiqTech TR4 coolers (see p102), the waterblock now features RGB lighting that can hook up to motherboard headers too. Prices start from £130 inc VAT for the 240mm version from **www.overclockers.co.uk**

RAZER™

BLADE 15

ULTRA FAST. ULTRA SMALL. ULTRA POWERFUL.

The new Razer Blade is the world's smallest 15.6" gaming laptop, striking the perfect balance of power and portability. We've redesigned the award-winning laptop to be more compact yet deliver even more performance and features, while adding a larger edge-to-edge display.

- World's smallest 15.6" gaming laptop (0.66" x 9.25" x 13.98")
- Full HD edge-to-edge display (4.9mm bezels), available 144Hz refresh rate, color calibrated
- 8th Gen Intel® Core™ i7-8750H 6 core processor, up to 4.1 GHz
- NVIDIA® GeForce® GTX 1060 or 1070 Max-Q Design VR Ready graphics
- Innovative vapor chamber cooling system with Gaming Mode power boost

AVAILABLE FROM

amazon | RAZERSTORE razer.com

"Gaming laptop" refers to Windows 10 clamshell device with discrete graphics, as of May 15 2018.

Letters

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

Remember old TIM

My gaming computer began crashing occasionally during the recent warm spell. My Intel Core i5-4670K rig that I built five years ago was affected by the high ambient temperature, and the fans couldn't cope. It was getting noisier as well. The CPU was overclocked to 4.3GHz using air cooling, and it was going above 99°C and throttling. I thought that the problem would resolve itself with cooler weather, but it didn't, so remedial action was required.

I removed the heatsink, which seemed looser than I remembered when I built it, and looked at the CPU surface. The TIM was completely dry, patchy and crumbly. A quick clean, reapplication and reassembly was needed, and the temperatures showed that the problem was fixed. So, for all those systems that you built a while ago, it might be worth checking the TIM before getting frustrated at your trusty system that has done you so well over the years.

Reapplying your TIM can make a huge difference to CPU temperatures

JONATHAN EALES

Ben: Sage advice here, Jonathan. Some types of TIM are more durable than others, and most types can all lose their effectiveness over time. If you're having thermal problems, it's always worth cleaning off the old TIM and reapplying new gunk.

More TR4 coolers please

Looking in the recent issue, there only seems to be one TR4 cooler on your Elite list. Is there any chance of a roundup review, covering water and air?

DAVID PRICE

Ben: The problem with TR4 is that the massive heatspreaders really need a full-cover coldplate for effective cooling, and that it's also a very niche socket – not many mainstream coolers do it out of the box, with several of them coming in separate TR4 versions that can't be used on other sockets, which is why TR4 isn't usually included in our cooler reviews. However, you'll be pleased to know that a TR4 cooler Labs is on the list for the near future.

Let kit go

Regarding James Gorbold's column in Issue 182, I managed to sell (well, actually got a colleague to sell!) some of my hardware, but, sadly, ended up disposing of some of the older kit, such as GeForce GTX 460 cards, as nobody seemed to want it.

One piece of hardware I can't bring myself to ditch is my quad-socket Opteron monster with 48 physical CPU cores in a huge Super Micro case, which was great for the bigadv Folding@home work units (remember those?) in 2012, but is redundant now. My latest PC build is – an NUC. Given the size of the Super Micro case, maybe I should use it as a bench!

JON WILLIAMS (AKA DOCJONZ)

James: It sounds like you had a similar issue to me, Jon – an emotional attachment to some old hardware. For me, the hardest gear to let go was also the big multi-socket systems that were great for the huge bigadv Folding@home units. My current PC is a little larger than your NUC (it's built in a Fractal Design Define C), but it's now the only PC I own. CPC

Twitter highlights

Follow us on Twitter at @CustomPCmag

Pc_Shed Nice to have something good to read delivered to your door. But @CustomPCMag what has happened to the @foldingathome league tables as they are not in the issue 182/November 2018?

Ben: We removed them – sadly not many people do Folding@home any more, and we couldn't justify giving it a whole page when it had so few results. As always, we're open to bringing it back if enough of our readers demand it, perhaps not a whole page though.

aazzgard Hi, when do you think prices for 1080 Ti cards will drop and where do you think they will drop to? I guess there will need to be a drop otherwise the new 2080 cards will be too expensive and not sell in great numbers.

Ben: I've addressed this issue on p8, and it's not good news I'm afraid – GTX 1080 Ti cards still cost at least £650 inc VAT, usually more. They may drop further, but I wouldn't get your hopes up yet.

WHEN'S THE NEXT MAG OUT?

NOV 8

Issue 184 of Custom PC will be on sale on Thursday, 8 November, with subscribers receiving it a few days beforehand.

Send your feedback and correspondence to letters@custompcmag.org.uk

COOLER MASTER

Make It Yours.

READY, SET, GAME.

MASTERBOX **MB510L** & **MB511**

- AGGRESSIVE **INTAKES**
- EDGE-TO-EDGE **TRANSPARENT SIDE PANEL**
- SUPPORT FOR A TOTAL OF **6 FANS AND WATER COOLING**

With the **MasterBox MB510L** and the **MasterBox MB511**, systems built for high demand gaming can breathe easy through the **mesh front panel**.
Along with the **aggressive intakes** in front, there is also **ventilation on top** for added thermal support.

Buy Now from **www.cclonline.com**

Reviews

Our in-depth analysis of the latest PC hardware

Contents

Gigabyte Aorus RGB Memory p19 / Nvidia GeForce RTX 2080 Founders Edition p20

Zotac GeForce RTX 2080 Ti AMP! p20 / Gigabyte B450 I Aorus Pro WiFi p26

Cooler Master Cosmos C700M p28 / Thermaltake Level 20 VT p30 / Samsung Portable SSD X5 p32

ViewSonic VP3268-4K p34 / MSI Optix MPG27C p36 / Custom kit p38

DDR4 MEMORY KIT

Gigabyte Aorus RGB Memory / £194 inc VAT (16GB, 3200MHz, dual-channel)

SUPPLIER www.morecomputers.com

It's rare that a motherboard maker gets into the memory market, and even rarer that it manages to offer a unique product compared with the rest of the field, which is already teeming with RGB LEDs and fancy heatsinks. However, Gigabyte's Aorus RGB Memory not only hits the nail on the head in terms of pricing, but also has a great solution to one of the biggest aesthetic issues with dual-channel RGB memory.

You might think we've used the wrong photo, and that this dual-channel kit should have just two modules. However, despite there being four modules in the Aorus RGB Memory box, it's only a dual-channel kit for the simple reason that two of the modules are dummies. These dummy modules contain only a sparsely populated PCB with no memory chips, but they do have a small section of contacts at one end of the base. These contacts enable them to tap into the SM bus signals to control their RGB lighting.

The dummy DIMMs fill in the gaps between modules if you don't fill all the slots. For example, if you buy a dual-channel kit for a four-slot motherboard, you end up with an annoying break in the lighting.

With memory prices at all-time highs, investing in four modules when you only need two of them simply isn't an option for a lot of people, though, and Gigabyte has come up with a good answer to the problem. Despite costing the same price as other 16GB, 3200MHz dual-channel RGB kits, you get four modules here. Only two of them are fully fledged memory modules, yet visually, they look and work like the active modules, and the lighting effects are synchronised across them too.

There's a range of effects from which to choose, although the options aren't quite as extensive as on Corsair's Vengeance RGB Pro modules. However, there's enough to keep most folks happy and you don't need a Gigabyte motherboard either. The company's Fusion Link software worked fine on our Asus test motherboard, although you'll need a Gigabyte board if you want to match the memory's lighting to your motherboard.

Meanwhile, the lighting itself is bold and punchy, although it isn't quite as accurate or vivid as Corsair's. For example, the white wasn't particularly clean and darker colours lacked pizzazz. However, the Aorus RGB Memory still looks fantastic with the modules bunched together.

Despite using Samsung B-die chips, we couldn't get our 3200MHz kit with 16-18-18-38 timings beyond 3333MHz, which is a tad disappointing given that most other similar kits we've tried have got to at least 3400MHz. The modules are fairly low-profile, though, measuring just 39mm and the heatsinks are attractive too.

Conclusion

Despite the lighting not quite being on a par with Corsair's Vengeance RGB Pro kits, and the lack of overclocking headroom, the fact you get four modules for the price of two, allowing you to occupy all four slots on a micro-ATX or ATX motherboard, is a fantastic bonus. The software worked without a hitch and the modules are some of the shortest RGB DIMMS we've tested too. As a result, Gigabyte's Aorus RGB memory comes highly recommended.

ANTONY LEATHER

/SPECIFICATIONS

Frequency 3200MHz
Timings 16-18-18-38
Voltage 1.35V
Height (from base) 39mm
Lighting Yes (RGB)

PERFORMANCE	DESIGN	VALUE	OVERALL SCORE
24/30	21/25	41/45	86%

VERDICT

Including two dummy modules to fill empty slots is a great idea and the kit is reasonably priced too.

Nvidia GeForce RTX 2080 Founders Edition

GRAPHICS CARDS

The Turing test

Nvidia GeForce RTX 2080 Founders Edition / £749 inc VAT

SUPPLIER www.nvidia.com

Zotac GeForce RTX 2080 Ti AMP! / £1,224 inc VAT

SUPPLIER www.scan.co.uk

We're a little bit in love with Nvidia's new GeForce RTX 2080 Founders Edition, despite its price. We'll get to all the stuff about ray tracing, deep learning and the new GPU architecture in a minute, but what first strikes you about Nvidia's own-brand card is that it's packaged as a truly premium product. It starts when you remove the lid of the box, and the card is revealed standing up on its edge, as if it's awarding itself to you as a trophy.

Even the card itself is beautifully designed, with a two-slot, all-metal chassis and backplate surrounding the PCB. The deep-milled grooves in the backplate look fantastic, and the design ensures that plenty of hot air is exhausted out of the rear vents, rather than out of the front of the heatsink into your case. This time, the Founders Editions also have two fans, rather than just one, as well as a vapour chamber. As first impressions go, Nvidia has got the design right, which is just as well, as it costs £749 inc VAT.

And if you thought that was a silly amount of money, wait until you see the price of the RTX 2080 Ti, where cards start at £1,100 inc VAT, and go all the way up to £1,224 for the Zotac AMP! card we're reviewing here. Buying a new RTX card is clearly going to be a serious investment, but is it worth it? That's a tough question to answer at the moment, as a lot of the new benefits of the new GPUs are impossible to gauge with current games.

/SPECIFICATIONS
NVIDIA GEFORCE RTX 2080 FOUNDERS EDITION

Graphics processor Nvidia GeForce RTX 2080, 1515MHz base clock, 1800MHz boost clock

Pipeline 2,944 stream processors, 64 ROPs

RT Cores 46

Tensor Cores 368

Memory 8GB GDDR6, 14GHz effective

Memory interface 256-bit

Bandwidth 448GB/sec

Outputs/inputs 3 x DisplayPort 1.4, 1 x HDMI 2b, 1 x VirtualLink

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

Catch some rays

Let's start with the headline feature of Nvidia's new Turing GPUs, which is real-time ray tracing – a feature so important to Nvidia that it replaced the 'G' in its 'GTX' brand with an 'R'. You can read all the detail about how ray tracing works, and how Nvidia is doing it, in our dedicated feature on p84, but we'll go through the basics here too.

Ray tracing is based on accurately modelling the way light splits, bounces, reflects, refracts and so on throughout a scene, by tracing the rays all the way from the virtual sources, through the scene and to the eye of the person viewing the scene. It's a process used extensively in cinematic special effects, and it's what makes the lighting in CGI scenes look especially realistic, as well as enabling

Zotac GeForce RTX 2080 Ti AMP!

incredibly shiny and reflective surfaces. It's also computationally very expensive, with a single frame taking a long time to render, even on dedicated hardware.

However, Nvidia has spent several years working on a way to achieve at least some of the effects of ray tracing in real time, partly by reversing the process, 'casting' a limited number of rays from the observer's point of view and tracing them around the scene, avoiding the compute cost of modelling light in areas of the scene that the observer can't see anyway.

We're not talking Pixar-level ray tracing in games here – rather than ray tracing entire scenes, game developers will instead take a hybrid approach, combining traditional rasterisation with limited ray tracing used for areas where you notice it most, such as reflections and shadows. Nvidia measures the ray-tracing performance of its new GPUs in Giga Rays per second, with the 1.21 Giga Rays per second figure for the RTX 2080 Ti multiplying the ray-tracing performance of the GTX 1080 Ti by nearly ten.

That's because the RTX GPUs now have specific hardware dedicated solely to ray tracing. As with the Pascal architecture, the GPUs are made up of Graphics Processing Clusters (GPCs), each of which contain Texture Processing Clusters (TPCs). In turn, these TPCs contain the usual Streaming Multiprocessors (SMs), each with four banks of stream processors (more on those later). However, unlike Pascal, each TPC now also contains a dedicated RT core for ray tracing. The RTX 2080 Ti contains 68 RT Cores, while the standard RTX 2080 has 46 of them.

It all sounds great, but the problem is that no games currently support real-time ray tracing. Future game launches are promised to support it, as well as patches for some games, including Shadow of the Tomb Raider, but there's nothing at the moment. It also doesn't help that DirectX games need to have access to Microsoft's DirectX Ray Tracing technology, and that isn't officially being released until the next Windows 10 update later this year.

We've only managed to run one piece of real-time ray-tracing software on our test card, which is a preview of a future 3DMark ray-tracing test that we received from Futuremark. There's no facility to record performance, or tweak the settings, and the company stressed that it's not necessarily indicative of the final test. We also had to enable Windows 10 Developer Mode to get it to run, but it then worked.

The preview showed that real-time ray tracing could indeed be achieved though. The short sequence showed a scene that clearly employed both rasterisation and ray-tracing techniques, centred on a spacecraft with various reflective surfaces. The Nvidia tech demos also show the potential for ray tracing to be used in water and eye reflections. If it ends up being widely used, it will make a world of difference to gaming – ray-traced armour and weapons in the next Elder Scrolls game would just be fantastic.

This preview of 3DMark's new ray-tracing test showed Nvidia's RT Cores working, with highly reflective surfaces on the spaceship

/SPECIFICATIONS

ZOTAC GEFORCE RTX 2080 TI AMP!

Graphics processor Nvidia GeForce RTX 2080 Ti, 1350MHz base clock, 1665MHz boost clock

Pipeline 4,352 stream processors, 88 ROPs

RT Cores 68

Tensor Cores 544

Memory 11GB GDDR6, 14GHz effective

Memory interface 352-bit

Bandwidth 616GB/sec

Outputs/inputs 3 x DisplayPort 1.4, 1 x HDMI 2b, 1 x VirtualLink

Power connections 2 x 8-pin

The DLSS image in Final Fantasy XV looks superior to the TAA one when you zoom in, with smoother curves and no artefacts

Future Tensor

The other main addition to Nvidia's Turing architecture is the Tensor Cores, which are found next to each bank of stream processors in the SMs – you get two Tensor Cores in each bank, for a total of eight in each SM. First seen in Nvidia's compute-centric Volta architecture, Tensor Cores are designed to speed up a calculation that's commonly performed in deep learning work, where you take a 4 x 4 matrix of numbers, multiply it by another 4 x 4 number matrix, and then add the result of that multiplication to another 4 x 4 matrix. According to Nvidia, thanks to the Tensor Cores, Turing SMs can calculate these problems in eight times the speed of the Pascal equivalents.

Nvidia is keen to port the fruits of its GPU-compute work to games

You might think that doesn't sound particularly gamey, but Nvidia is clearly keen to port a lot of the fruits of its GPU-compute work over to the game industry, and it may be onto something here. The idea is that, because Nvidia now has masses of compute power at its disposal, it can take a gaming mathematical problem, let its massive neural network solve it, and then compress the solution to the point where it can be crunched by Tensor cores. It then packages it all up and sends it to you via GeForce Experience.

One of the first successes is what Nvidia calls Deep Learning Super-Sampling (DLSS), an anti-aliasing method. It's been a long time since we've seen the term 'super-sampling' used to describe anti-aliasing – it's a technique that effectively samples every single pixel in a scene a certain number of times – it looks great, but it saps a lot of graphics card resources.

The 3dfx Voodoo5 cards first introduced us to anti-aliasing via super-sampling back in the early 2000s, but it hit performance hard, and more efficient anti-aliasing techniques were quickly developed to ease the burden. 3dfx's cards were only super-sampling each pixel twice or four times, but Nvidia has fed thousands of reference images with 64x super-sampling (that's each pixel, sampled 64 times) into its neural network. It can then compare these 64x super-sampled images with the standard images, with no anti-aliasing, and spend its deep learning resources on spotting the differences between them, learning how to make the standard images match the super-sampled images as closely as possible.

After working continuously on this problem with a load of GPU-compute resources geared towards maintaining visual fidelity and avoiding artefacts, the neural network can gradually perfect an anti-aliasing algorithm.

The result is DLSS – an anti-aliasing method that should avoid some of the problems with temporal anti-aliasing, such as artefacts, distortion, transparency issues and so on, while also having a smaller performance impact, as most of the hard compute work has effectively already been done. Nvidia has announced 25 supporting titles for DLSS, including Shadow of the Tomb Raider, We Happy Few, PUBG and Final Fantasy XV.

As with the real-time ray tracing, though, there's just one problem – no games support DLSS yet. Again, there was only one test available to us at the time of going to press –a custom Nvidia version of the Final Fantasy XV Windows Benchmark, using Fraps to gauge performance. It came with two batch files – one to run the benchmark with temporal anti-aliasing (TAA), and one to run it with DLSS. We ran them both on the RTX 2080 and 2080 Ti, and we also ran the TAA test on a GTX 1080 Ti card for reference.

It's not an ideal test, for a number of reasons. There's no way to change the settings or resolution – it runs at 3,840 x 2,160 with 'Custom' settings, and there's no way to see

those settings. Naturally, we should be sceptical about a benchmark supplied directly from Nvidia that doesn't let us see or change the settings.

It does seem to work though. Nvidia told us that the image quality should be similar between TAA and DLSS in this test, with the latter being quicker. However, to our eyes, the DLSS image quality is slightly superior, offering a smoother image (although you really have to zoom in to see it). More importantly, DLSS appears to offer a substantial performance improvement, with the minimum jumping from 21fps to 28fps on the RTX 2080, and from 28fps to 36fps on the RTX 2080 Ti. As with ray tracing, though, only time will tell if real games can get a genuine boost from it.

Inside the GPU

So that's two new core-types in the Turing architecture, but the rest is basically like Pascal, right? Nope, not quite. Believe it or not, the stream processors themselves are a little different too. Floating point instructions are generally used much more commonly than integer instructions – just in case you're not up on your maths lingo, integers are whole numbers, whereas floating point numbers have a decimal point, generally making calculations more complex.

With previous GPU designs, both integer and floating point instructions shared the same data path, which sometimes resulted in integer instructions holding up the floating point ones and causing a gridlock. Nvidia's solution is to split the SM into floating point (FP32) processors and integer (INT32) processors, each with a separate data path, and with the ability for instructions to be executed on both types of processor simultaneously. According to Nvidia, this system increases the flow of floating point instructions by 36 per cent. So rather than having a single block of 128 FP32 processors in each SM, there's now a block of 64 FP32 processors, and another block of 64 INT32 processors.

Of course, all this hardware occupies a massive amount of silicon real estate. In fact, the TU102 GPU used by the RTX 2080 Ti has a massive 754mm^2 die, containing 18.6 billion transistors. Two of its TPCs are also disabled, meaning there's potentially room for a further top-end TU102-based card in the future – we don't want to think about how much that will cost though. Likewise, one of the TPCs in the RTX 2080's TU104 GPU is also disabled.

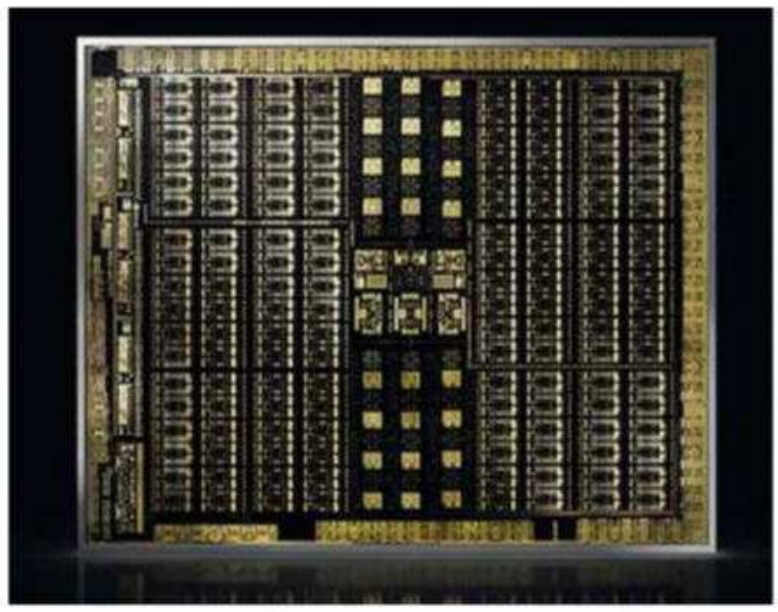
Memory

The other major new introduction with the RTX cards is GDDR6 memory, improving efficiency and offering much more bandwidth. Both the RTX 2080 and the RTX 2080 Ti have their GDDR6 memory clocked at 7GHz, effectively running at 14GHz. As standard, the RTX 2080 has 11GB of GDDR5 memory, attached to a 352-bit wide interface (it would be 384-but, but one 32-bit memory controller is disabled), and 88 ROPs, for a total memory bandwidth of 616GB/sec. Meanwhile, the RTX 2080 has 8GB of GDDR6 memory attached to a 256-bit interface and 64 ROPs, for a total of memory bandwidth of 448GB/sec.

Ins and outs

Finally, there are a couple of physical changes to the RTX cards when compared with their Pascal-based predecessors. Firstly, there isn't a DVI output in sight. Secondly, there's now a Type-C USB port on the rear I/O panel, which supports VirtualLink, a standard devised to reduce the cabling from PCs to VR headsets, effectively providing up to 35W of power, data via USB 3.1 Gen2 and video via DisplayPort HBR3 over a single cable.

Thirdly, you might notice that the SLI connector at the top looks a bit different. Yes, the SLI connector is dead; long live NVLink – a connector that's come from Nvidia's Tesla world to join the GeForce world, enabling GPUs to talk to each



Nvidia's new Turing GPUs contains a huge amount of silicon, but not all of it is being used at the moment

other without solely relying on the PCI-E 3 bus. There's one 8x NVLink 2 link available to the RTX 2080, and two links available to the RTX 2080 Ti, although only 2-way SLI is supported by either card.

Performance

With little way to test Nvidia's ray tracing and DLSS features in proper games, we ran both the RTX 2080 Founders Edition and Zotac RTX 2080 AMP! through our games benchmark suite, which now also features Shadow of the Tomb Raider. In terms of raw frame rates in today's games, there's little to distinguish the RTX 2080 Founders Edition from a GTX 1080 Ti – just a few frames per second separated the two cards in all our tests. It's clearly a very capable card, playing most of our games at solid frame rates, even at 4K.

There was one problem with both GPUs, which was running our Total War: Warhammer II benchmark. Both the RTX 2080 and 2080 Ti noticeably stuttered a couple of times in the test, dropping the minimum frame rate significantly. This problem appears to be an issue with the 411.51 driver supplied to test the RTX cards, as it caused the same problems with our GTX 1080 Ti card, which had no problem at all when using the previous 399.24 driver. Either way, it's clear from the average frame rates that the RTX GPUs have the power to play the game fine – hopefully the stuttering will be fixed in a future driver update.

The Turing flagship, though, is the RTX 2080 Ti, which raced through our game tests like a sword through soft margarine. Even the brand-new Shadow of the Tomb Raider never dropped below 48fps at 4K, and its minimum hit 109fps at 1080p, with an average of 146fps – great if you have a high refresh rate monitor. Not even our usually gruelling Deus Ex: Mankind Divided 4K benchmark could stop it, with its minimum of 44fps and 52fps average being well above any previous results we've seen.

The performance of Zotac's RTX 2080 Ti AMP! card was even better, with a mind-blowing 125fps minimum in Doom at 4K, a 47fps minimum in Deus Ex at the same resolution and 52fps in Shadow of the Tomb Raider. It doesn't have the classy looks and design of the Founders Edition cards, and it takes up a fair bit of room, but it's quiet and very fast.

Of course, one price you pay for so much silicon running at high speed is power consumption. Running Unigine Superposition on our overclocked Core i7-8700K graphics test rig, the Zotac 2080 Ti AMP! pushed the system to consume 357W, and 296W on the RTX 2080 Founders Edition. That's not terrible – it's lower than the 376W from the slower Radeon RX Vega64, and the RTX 2080's result is also lower than the 338W form the GTX 1080 Ti, showing that the RTX 2080 is more power-efficient.

What these figures don't show you, however, is how much power will be consumed when the Tensor Cores and RT Cores are fully engaged, as well as all the rasterisation hardware. The Zotac card has two 8-pin PCI-E power sockets, so it may need more power at some point.

Overclocking

At stock speed, the GPUs have a boost clock of 1710MHz and 1545MHz respectively. However, the RTX 2080 Founders Edition is slightly overclocked to give you a boost clock of 1800MHz, and the Zotac RTX 2080 Ti is also overclocked, to give you a boost clock of 1665MHz.

There's also more overclocking headroom. For starters, we had no trouble overclocking the memory all the way to 8GHz (16GHz effective) on both cards. We also managed to add a further 66MHz to the RTX 2080's GPU, and a further 75MHz to the RTX 2080 Ti GPU. Both cards responded well, delivering a few extra frames per second in our 4K Shadow of the Tomb Raider test. There was a significant boom in power consumption, though, with our system consuming nearly 400W with the Zotac RTX 2080 Ti AMP! overclocked, and 364W with the overclocked RTX 2080.

Conclusion

The problem for Nvidia at the moment is that the main headline features of the Turing architecture can't be used in any real games yet. It's a bit like when the GeForce3 came out, with support for DirectX 8 shaders, but no games were using them. In that case, it wasn't really until the next generation of DirectX 9 GPUs surfaced that shaders really started to get commonly used, and that's the worry here. If real-time ray tracing is indeed going to be the next big thing in gaming graphics, with lots of new games supporting it without a massive performance penalty, then the RTX 2080 and 2080 Ti will be extremely tempting purchases, even at these prices. Ray tracing just looks amazing, and the prospect of real-time ray tracing in games is tantalising.

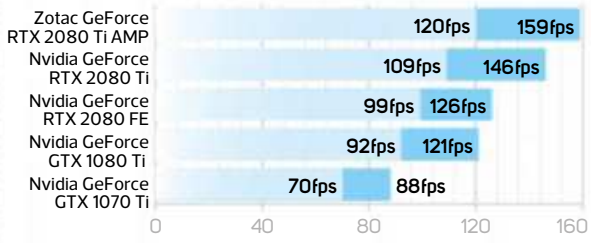
Likewise, we may see games benefit from Nvidia's Tensor Cores too, but there's no way to gauge it at the moment. That just leaves us with today's games, using standard rasterisation, and while the RTX cards are fast in these applications, they're not fast enough to justify their colossal prices. RTX 2080 cards cost at least £100 more than GTX 1080 Ti cards at the moment, but they're only slightly faster. The RTX 2080 Ti does at least provide a significant performance boost in games, but it's not one that can justify prices of well over a grand. If you have the money, and want the fastest graphics card possible, the Zotac GeForce RTX 2080 Ti AMP! fits the bill, but it's only a card for extreme enthusiasts with a lot of cash to splash.

There are several factors here contributing to the prices – the cost of Nvidia's research and development, the cost of producing so much silicon and, of course, the lack of competition from AMD. However, until we can prove that the new features in Turing are truly worth having, these graphics cards are extremely overpriced.

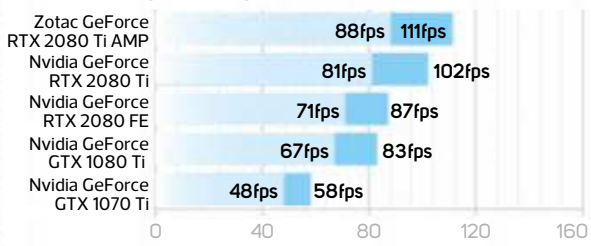
BEN HARDWIDGE

SHADOW OF THE TOMB RAIDER

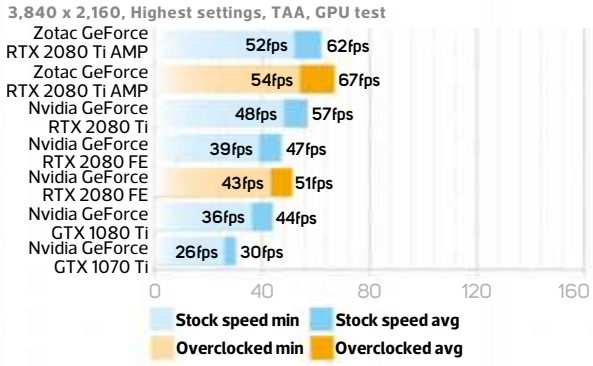
1,920 x 1,080, Highest settings, TAA, GPU test



2,560 x 1,440, Highest settings, TAA, GPU test

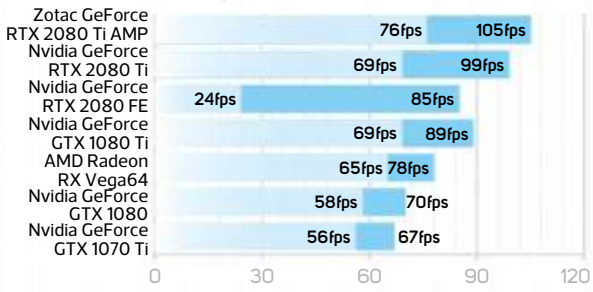


3,840 x 2,160, Highest settings, TAA, GPU test

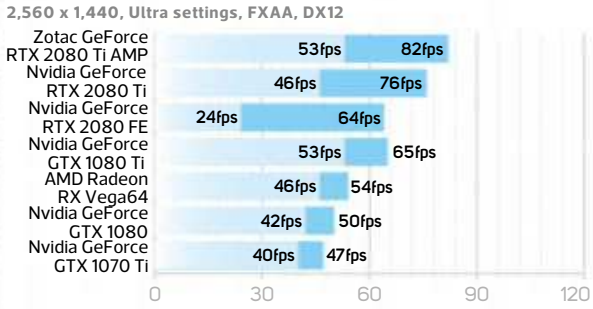


TOTAL WAR: WARHAMMER II

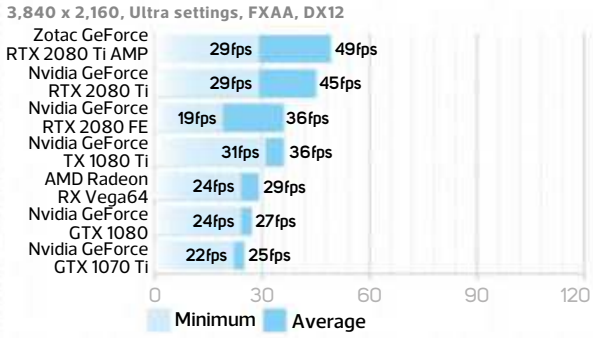
1,920 x 1,080, Ultra settings, FXAA, DX12



2,560 x 1,440, Ultra settings, FXAA, DX12



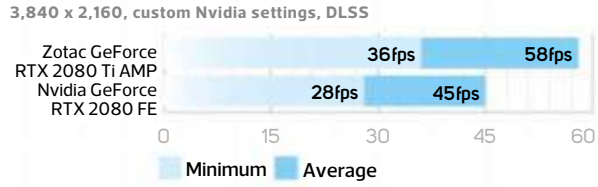
3,840 x 2,160, Ultra settings, FXAA, DX12



FINAL FANTASY XV BENCHMARK

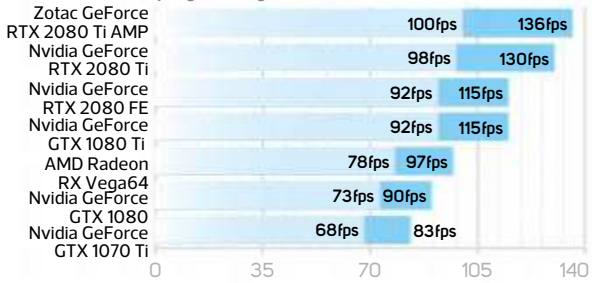
3,840 x 2,160, custom Nvidia settings, TAA

3,840 x 2,160, custom Nvidia settings, DLSS

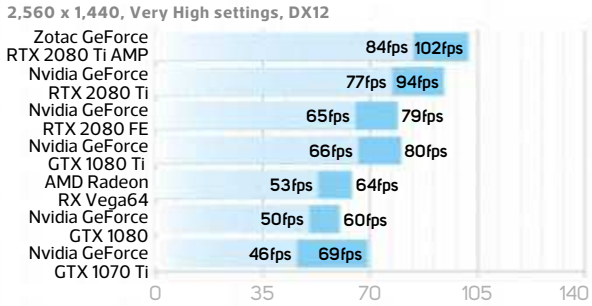


DEUS EX: MANKIND DIVIDED

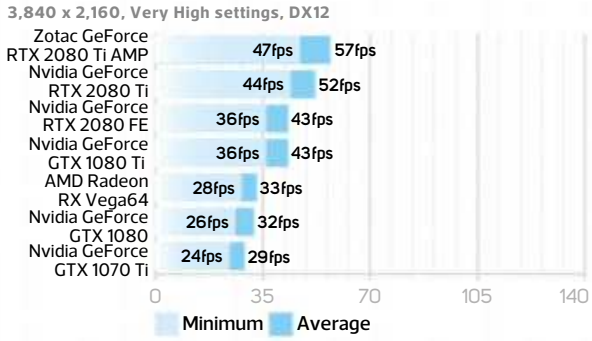
1,920 x 1,080, Very High settings, DX12



2,560 x 1,440, Very High settings, DX12

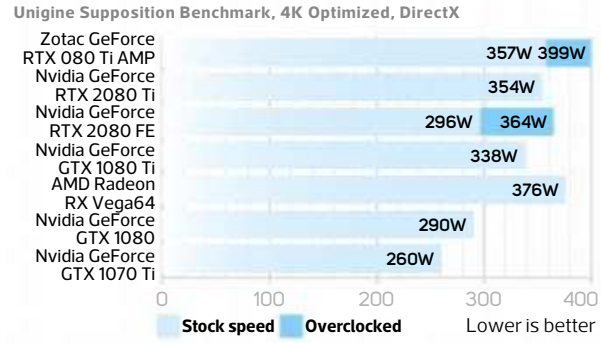


3,840 x 2,160, Very High settings, DX12



TOTAL SYSTEM LOAD POWER CONSUMPTION

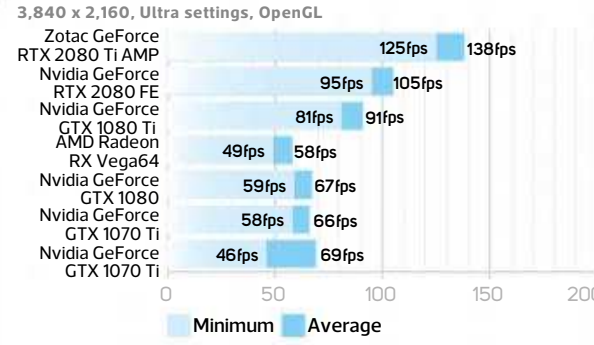
Unigine Supposition Benchmark, 4K Optimized, DirectX



DOOM

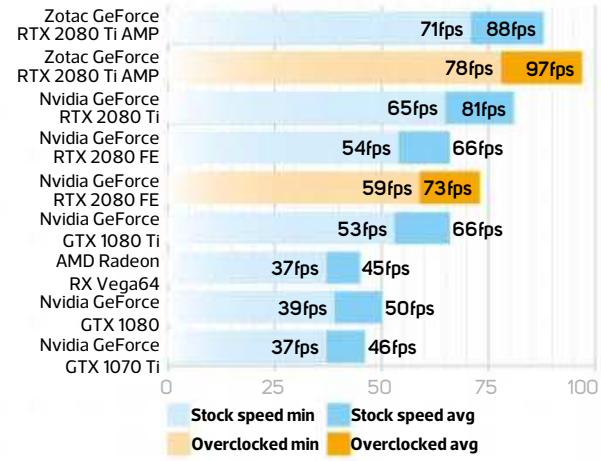
2,560 x 1,440, Ultra settings, OpenGL

3,840 x 2,160, Ultra settings, OpenGL



UNIGINE SUPERPOSITION BENCHMARK

4K Optimized, DirectX



NVIDIA GEFORCE RTX 2080 FE

PERFORMANCE 36/40

FEATURES 20/20

VALUE 14/40

OVERALL SCORE 70%

ZOTAC GEFORCE RTX 2080 Ti AMP!

PERFORMANCE 40/40

FEATURES 20/20

VALUE 10/40

OVERALL SCORE 70%

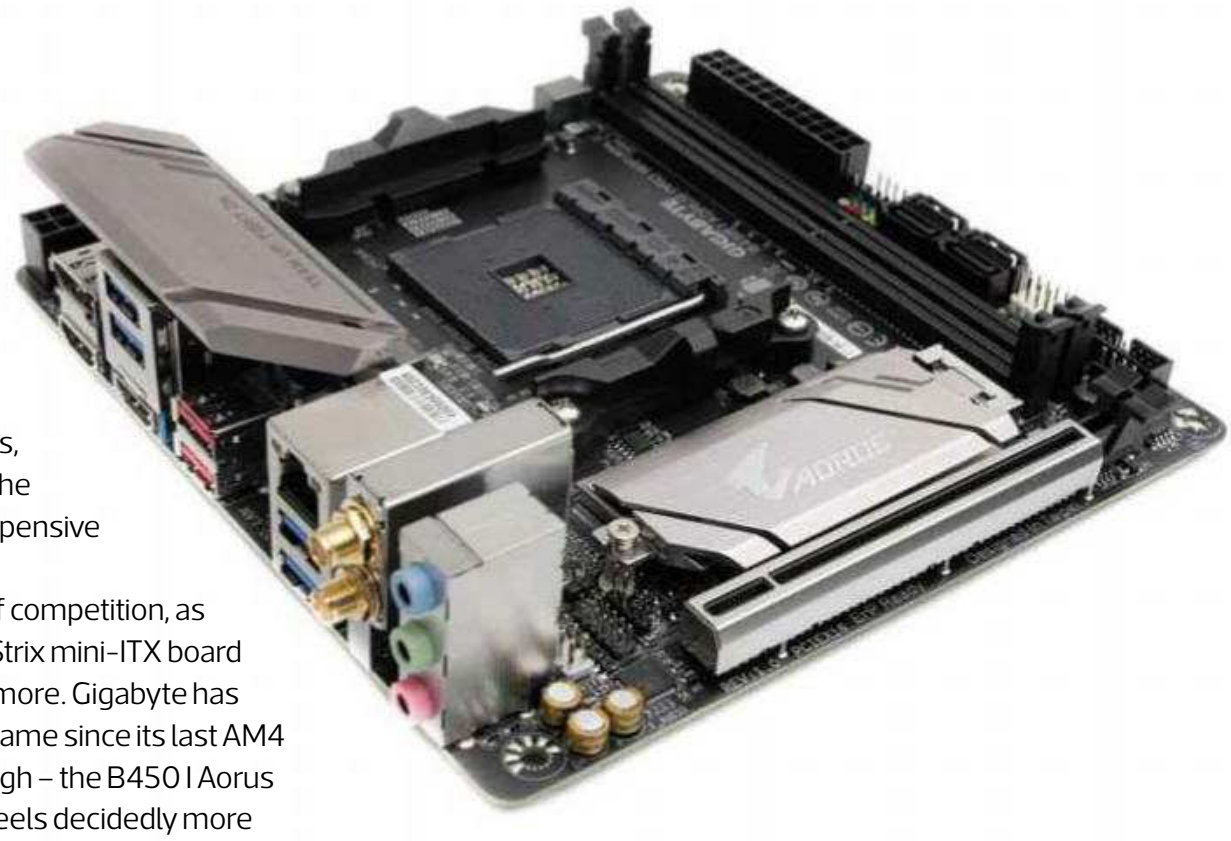
VERDICT

Great 4K speed, and the potential for much more, but these cards can't justify their high prices yet.

MINI-ITX B450 MOTHERBOARD

Gigabyte B450 I Aorus Pro WiFi / £130 inc VAT

SUPPLIER www.overclockers.co.uk



Gigabyte's B450 I Aorus Pro WiFi is aiming high with its RRP of £130 inc VAT, especially considering it uses AMD's B450 chipset as opposed to X470. Thankfully, on mini-ITX boards at least, there's next to no difference between the two chipsets, as there's no space to make use of the additional features that the more expensive X470 chipset offers anyway.

However, Gigabyte has some stiff competition, as the B450 version of the Asus ROG Strix mini-ITX board retails for only £20 more. Gigabyte has certainly upped its game since its last AM4 mini-ITX effort though – the B450 I Aorus Pro WiFi looks and feels decidedly more premium than the last-generation B350N Gaming AC WiFi.

There's a large VRM heatsink covering the 4+2 phase power circuitry, and you also get a large M.2 heatsink with the port beneath it supporting either 4x PCI-E 3 or SATA-based SSDs. The heatsink dropped the temperature of our Samsung 960 Evo by 9°C too, so it's definitely worth putting it to use. There's no second port, though, so adding extra storage will involve using of one of the four SATA 6Gbps ports, which are all handily located on the edge, next to the DIMM slots.

The rest of the PCB is fairly spartan, and there's a severe lack of fan headers. There are just two fan headers on the PCB, so you'll need to invest in some splitter cables if you need to power more than a single case fan. What's more, header-powered, dual-fan all-in-one liquid coolers will be tricky to set up too.

The rear I/O panel also seems to be at odds with the PCB in terms of features, as it's bristling with useful connectors. There's on-board 802.11ac Wi-Fi and Bluetooth 5 support, six Type-A USB ports, including two USB 3.1 ports, and not a sign of USB 2 either.

There's a trio of digital display outputs too, and an Intel-controlled LAN port. The only disappointment on the rear panel is that, despite the board sporting Realtek's superb ALC1220 audio codec, there are only three audio outputs. There's no optical output, and connecting a 7.1-channel speaker system will require using the case's 3.5mm audio output via the on-board audio header. There's little by way of lighting out of the box either, but there's a row of RGB LEDs underneath the right side of the PCB, plus a single RGB header for LED strips.

The fan control section of the EFI is also excellent

/ SPECIFICATIONS

Chipset AMD B450

CPU socket AMD Socket AM4

Memory support 2 slots: max 32GB DDR4 (up to 3200MHz)

Expansion slots One 16x PCI-E 3

Sound 8-channel Realtek 1220

Networking Intel Gigabit LAN

Overclocking No base clock overclocking, max CPU multiplier 63x; max voltages: CPU 1.5V, RAM 2V

Ports 4 x SATA 6Gbps (B450), 1 x M.2, 4 x USB 3, 4 x USB 3.1 Type-A, 1 x LAN, 3 x surround audio out

Dimensions (mm) 170 x 170

Performance

We initially had issues firing up Gigabyte's System Information Viewer Windows monitoring software, but these problems were fixed when Gigabyte sent us the B18.0522.1 update for it – you'll need to do the same if you experience the same issues. However, Gigabyte's EasyTune overclocking software worked fine.

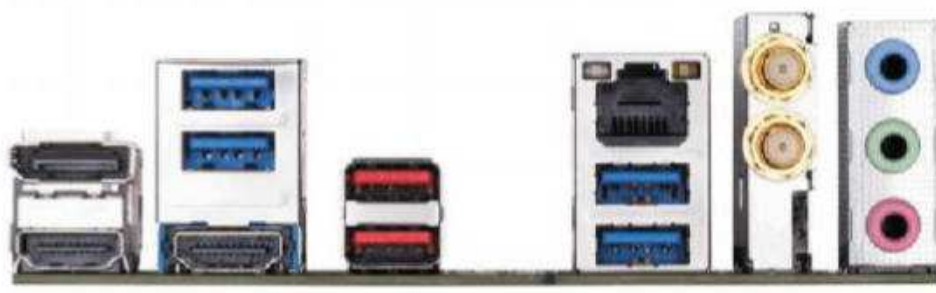
The fan control section of the EFI is also excellent, making it even more of a shame that there are just two fan headers. The rest of the EFI could do with some improvements too; it looks dated compared with the competition, with typical overclocking settings often spread across several tabs, while the Precision Boost Overdrive controls are bizarrely located in the peripherals section.

We managed to overclock our Ryzen 7 2700X to the usual 4.25GHz frequency and, despite the lowly power circuitry, the board held up under sustained multi-threaded load for a good five minutes.

However, it eventually succumbed and the software revealed that extremely high VRM temperatures were the likely cause, with the CPU never topping 85°C. It was stable enough to pass all our benchmarks, but the B450 I Aorus Pro WiFi isn't an ideal candidate for an overclocked 8-core CPU in multi-threaded tasks.

At stock speed, the system score of 196,474 was typical for an AM4 board using our Ryzen 2700X and our overclock saw this rise to 210,604 – again, similar to X470 boards we've tested.

The idle power consumption is a concern, though, and was a feature of many B450 boards we've tested, both at



HOW WE TEST
PAGE 42

1 **A large VRM heatsink covers the 4+2 phase power circuitry next to the CPU socket**

2 **The Realtek ALC1220 audio sounds excellent, but it could do with more audio outputs**

3 **The hefty M.2 heatsink dropped the temperature of our Samsung 960 Evo by 9°C**

stock speed and when overclocked, and the load power draw numbers aren't too clever either.

Thankfully, the audio performance was excellent, with noise and dynamic range levels of -110dBA and 111dBA respectively. The board managed 3,392MB/sec and 1,871MB/sec read and write speeds with our Samsung 960 Evo M.2 SSD too. All in all, it performs on a par with an ATX AM4 board.

Conclusion

We had high hopes for the B450 I Aorus Pro WiFi – it looks great and has stand-out features such as 802.11ac Wi-Fi, Realtek ALC1220 audio, an M.2 heatsink and large VRM heatsink. However, it's let down by its EFI, a lack of VRM cooling and lowly CPU power circuitry that undoubtedly led to our CPU throttling back under load. There are also only three audio outputs, no optical output and just two fan headers.

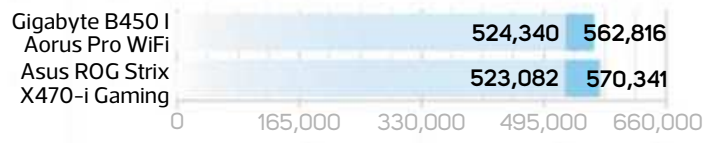
Three fan headers is the bare minimum for a typical enthusiast motherboard, but as it stands, you'll be left wanting if you use the B450 I Aorus Pro WiFi with any setup other than a single-fan CPU cooler and a single case fan. As a result, if you want to overclock your Ryzen CPU, the Asus ROG Strix B350-I Gaming or its X470 counterpart are your best bet while, for less cash, Gigabyte's own AB350N-Gaming WiFi is a good choice for a budget mini-ITX system at stock speed, although it doesn't support AMD's StoreMI technology, and you'll need an EFI update to support the latest CPUs. Gigabyte has made some superb mini-ITX boards for Intel CPUs, making it a real shame to see this AM4 board fall short.

ANTONY LEATHER

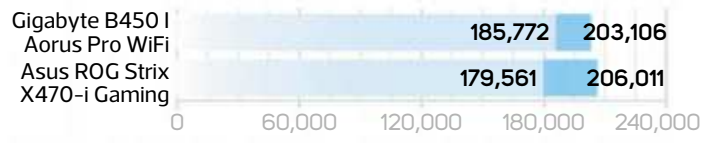
CPC REALBENCH

GIMP IMAGE EDITING

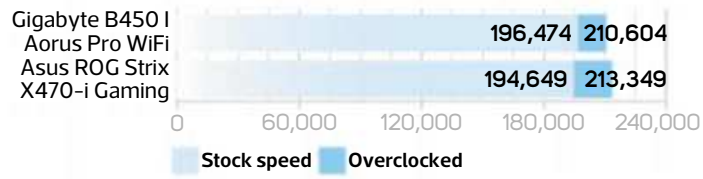
HANDBRAKE H.264 VIDEO ENCODING



HEAVY MULTI-TASKING



SYSTEM SCORE

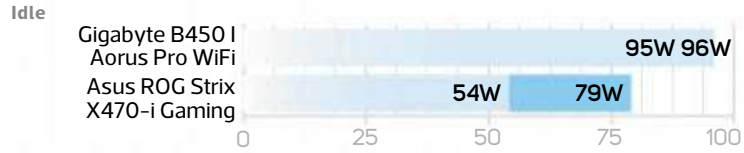


ASHES OF THE SINGULARITY

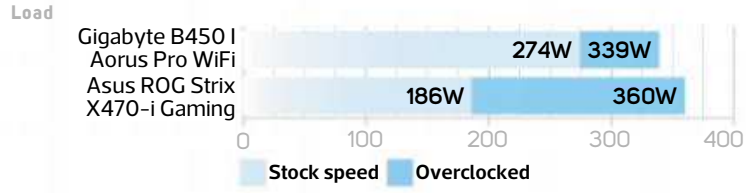
DX12 CPU Benchmark, 1,920 x 1,080, High Settings

TOTAL SYSTEM POWER CONSUMPTION

Idle



Load



PERFORMANCE 32/35

FEATURES 25/35

VALUE 20/30

OVERALL SCORE 77%

VERDICT

Decent performance and great audio, but it desperately needs more fan headers, and the EFI and VRM cooling need some attention too.

ATX CASE

Cooler Master Cosmos C700M / £430 inc VAT

SUPPLIER www.scan.co.uk

Cases we review don't often breach the £200 mark, let alone £400, especially from a mainstream brand. However, Cooler Master's new Cosmos C700M is an absolute monster and, unlike many other large expensive cases such as the SilverStone TJ11, it's not just a large metal box. In fact, it's one of the most tweakable cases we've seen.

Of course, at £430 inc VAT, all the features in the world won't make it affordable, and there's plenty of cases that offer the same space and some of the features for half the cash. However, the sheer amount of technology packed into the C700M almost makes you disregard the price tag and reach for your trembling wallet. It has the best lighting we've ever seen, with bright and vivid RGB diffuse strips of multiple LEDs running parallel down the front, then over the top of the chassis with two more on the base either side. As there are numerous individually controllable LEDs, the Cosmos C700M can produce some dazzling displays.

The spaceship-like design isn't garish or cheap-feeling

Meanwhile, the exterior is made from brushed steel and brushed-effect plastic, and build quality is great. The spaceship-like design isn't garish or cheap-feeling. The front panel has a plethora of ports and buttons, including a USB 3.1 Type-C port, plus a 4-channel RGB lighting controller that can cycle through several static colours as well as lighting effects.

Cooler Master has wired up connectors for all major motherboard RGB headers too, if you want to synchronise the lighting with other components. The front panel also sports a dual-mode fan controller, with six 4-pin ports that offer three fixed fan speeds, or you can switch to PWM mode courtesy of a 4-pin cable that can connect to a spare motherboard header.

The interior looks like it means business too, and there's staggering amount of customisation on offer. The motherboard can sit in standard or inverse orientations, as well as rotated 90 degrees in chimney mode with the CPU cooler blowing air out the roof. Components inside the case can switch sides to cater for this arrangement too, as can the side panels. There's also an adjustable graphics card mount, which allows it to sit in the middle of the case with your graphics card placed as the showpiece, either horizontally or at an angle.

This mount can also be installed in the roof, so the graphics card hangs vertically with its cooler facing the huge tempered glass window. Multi-GPU fans will be delighted by the possibility of using two of these mounts, so a pair of graphics cards can stand on either side of the motherboard, and a single riser cable is included too.

Meanwhile, cable routing is excellent, and the mass of cables for the fans, ports and lighting are individually threaded out of the box in clips inspired by server racks, with plenty of anchor points for additional cables and a large cover to hide them once you've finished.

There's a good mix of storage options too, with four dedicated 2.5in SSD mounts, plus five hard disk mounts that can also house SSDs. There's also a hidden 5.25in bay, although access via the front is awkward, as you need to pull out the entire front panel – it's not an ideal setup if you plan to use it regularly.

As you'd expect, there's plenty of room for water-cooling components as well, with several pump and reservoir mounts. The roof section has space for up to 360mm or 420mm radiators, measuring up to 70mm deep and, if you get rid of the 5.25in bay, there's space in the front for the same radiator setup too. Also, by swapping the top of the PSU cover with a vented bracket, you can mount fans or a 240mm radiator on top.

In terms of out-of-the-box airflow, the Cosmos C700M is equipped with a trio of front 140mm fans and a single rear 140mm fan, so it should cope well as standard if you'll be air-cooling your PC. The air-cooling credentials are further bolstered by large mesh-covered vents in the front and the roof.

/SPECIFICATIONS

Dimensions (mm) 651 x 650 x 306 (W x D x H)

Material Steel, plastic, glass

Available colours Grey, silver, black

Weight 23.4kg

Front panel Power, 4 x USB 3, 1 x USB 3.1 Type-C, stereo, mic

Drive bays 4 x 2.5in, 5 x 2.5/3.5in 1 x 5.25in

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

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

CPU cooler clearance 198mm

Maximum graphics card length 490mm

ELITE
NEW ENTRY
P64

1 **The motherboard can be inverted or even rotated by 90 degrees**

2 **The front panel sports controllers for fan speeds and RGB lighting**

3 **The roof section has space for 420mm radiators up to 70mm deep**

Performance

At full speed, the fans were still reasonably quiet, with just a deep thrum audible from outside the case. With one fan pointing straight at the CPU cooler, it wasn't surprising to see the CPU delta T reach an impressively low 50°C, matching the SilverStone Primera PM01 RGB and bettering the Corsair Crystal Series 570X.

Switching to the minimum fan speed saw this figure rise by just 3°C with a noticeable drop in noise, so it's definitely worth optimising your fan speeds.

Likewise, the GPU delta T only dropped from 51°C and 52°C with the fans set to minimum speed, so it's a no-brainer to use the lowest fan speeds.

Conclusion

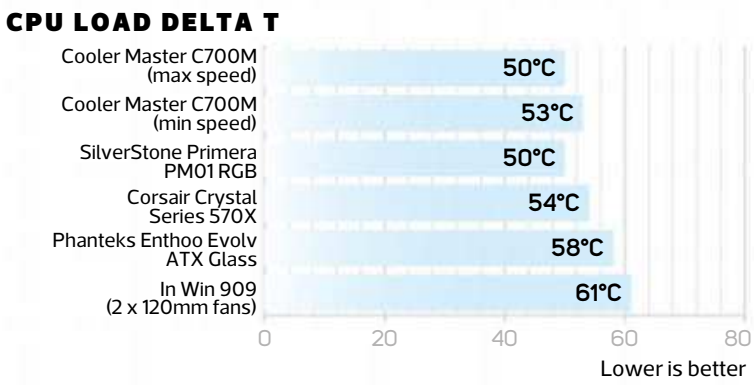
Building a PC in the Cooler Master Cosmos C700M and tinkering with all its features took up most of a day, so we suggest dedicating an entire weekend to building a high-end PC inside one – several if you'll be water-cooling it too. You'll also need an extra hand to lift it if you'll be kitting it out with water-cooling gear, as it weighs over 23kg on its own. The price is extreme, but so is the case and its features, from the RGB lighting to the configurable interior and spaceship-like exterior.

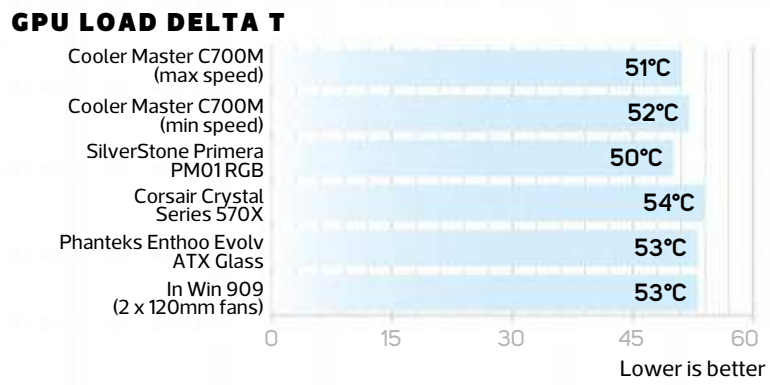
We only have two small niggles. Firstly, while Cooler Master supplies Velcro ties for cables, they're already neatly used with the standard case cables. Comparatively, several cheaper cases supply additional Velcro ties that are quicker and easier to use.

Also, there's a lot of plastic on the exterior, but the design blends it well with the metal. Cooler Master has turned the Cosmos C700M up to 11, and you pay for it, but it's definitely the case we'd use if we were building the PC of our dreams.

ANTONY LEATHER

TEMPERATURE RESULTS





COOLING 27/30

FEATURES 19/20

DESIGN 28/30

VALUE 16/20

OVERALL SCORE 90%

VERDICT

A stunning mix of versatile, cutting-edge features with and amazing lighting and design. It's expensive, but worth it if you want the very best.

MICRO-ATX CASE

Thermaltake Level 20 VT / £100 inc VAT

SUPPLIER www.overclockers.co.uk

If you want to build a monstrous PC in a dominating chassis then Thermaltake has some excellent options. The Core X1 for example, is the biggest mini-ITX case we've seen and could probably house an ATX system with extensive water cooling too. They don't exactly scream quality, and can be a little tinny, but for the price, they're hard to beat in terms of sheer expandability. With the new Level 20 series, though, the company is taking the concept of the Core X series and sprucing up the design, with the Level 20 VT shrinking in size too. Despite offering a home for a micro-ATX motherboard, it's much smaller than the mini-ITX Core X1.

It's completely clad in tempered glass, with curved edges at the front

Externally, the cases couldn't be more different. While the Core X series had steel panels with acrylic windows, the Level 20 VT is completely clad in tempered glass, with curved edges at the front to break up the otherwise boxy design. It measures only 35cm tall, yet it has enough CPU cooler clearance for heatsinks up to 185mm tall, thanks to the fact the motherboard is mounted horizontally, with clearance for graphics cards up to 350mm long. However, its width of 33cm and depth of 43cm mean that it has a sizeable footprint you'll need to consider if you intend to place it on top of a desk.

The front panel has a generous count of four USB ports, two of which are USB 3, plus the usual power and reset buttons, and audio mini-jacks. The panels are held in place with thumbscrews and even the base has a slide-off panel that enables you to install the PSU and access the drive bays here too. With all the panels removed, installing your hardware is blissfully easy.

The base offers a handy place to stow cables, as well as three drive bays that support both 3.5in and 2.5in drives, with the former making use of tool-free fittings that secure the drives in place. There are three dedicated, tool-free 2.5in mounts on the side of the case too, with SSDs simply clipping into place with no need to deal with fiddly screws. These bays are removable, as are the 3.5in ones, so you can remove the unwanted bays if you only have one hard disk or SSD.

Unfortunately, Thermaltake hasn't included an exhaust fan as standard, which will result in higher than average CPU temperatures, but there is a large 200mm fan included in the front section. This area can also house a pair of 120mm or 140mm fans, as well as a single 120mm or 140mm radiator, or even a 180mm or 200mm radiator. These fan mounts and 120mm of clearance behind them also make the front an ideal location for a combined pump and reservoir, especially if you're using a pump-to-fan mount bracket such as EK Water Blocks' EK-Uni pump bracket.

The roof also offers excellent radiator support, with side-by-side fan mount beams that can house four 120mm fans or a pair of 240mm radiators, expelling air out of the reasonably sized vents beneath the glass panel. You can also install a single 280mm or 240mm radiator here, and the beams are even removable to allow you to fit your radiator to them outside of the case, while the rear fan mount is limited to 120mm fans.

Finally, the PSU area has its own mesh dust filter, which can slide out for cleaning, while the front section has a large mesh panel that's screwed in place, requiring you to pop off the front panel to clean it. There are several large gaps at the bottom of the case, though, which allow air into the chassis, and these gaps could potentially allow dust into the case too, as they're unguarded by the filter.

Performance

Thermaltake claims the front fan is limited to just 800rpm and a noise level of 13dBA, but at full speed, it was quite audible, with a high-pitched airflow noise that made it the

/SPECIFICATIONS

Dimensions (mm) 330 x 430 x 348 (W x D x H)

Material Steel, plastic, glass

Available colours Black

Weight 8.7kg

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

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

Form factor(s) Micro-ATX, mini-ITX

Cooling 2 x 120/140mm or 1 x 200mm front fan mounts (1 x 200mm fan included), 4 x 120/2 x 140mm roof fan mounts (fans not included), 1 x 120/140mm rear fan mount (fans not included), 2 x 120mm base fan mounts (fans not included)

CPU cooler clearance 185mm

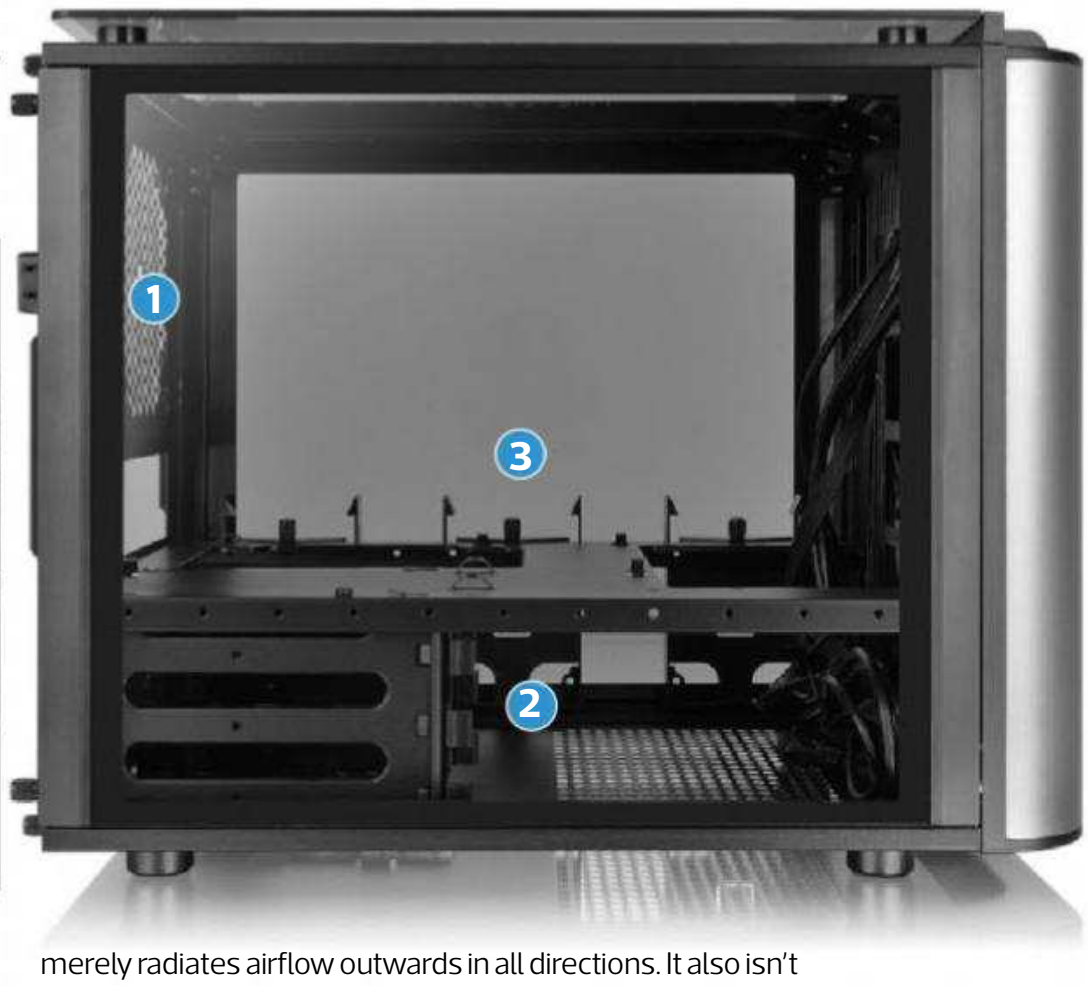
Maximum graphics card length 350mm

HOW WE TEST
PAGE 42

1 There's a 140mm exhaust fan mount at the back, but no fan is included

2 The base offers a handy place to stow cables under the motherboard tray

3 There's enough clearance for CPU coolers up to 185mm tall



loudest component in our test system, yet it didn't dish out a particularly large amount of air, resulting in a mediocre GPU delta T of 59°C.

This result is 4°C warmer than that of the Corsair Crystal Series 280X and 2°C warmer than Cooler Master's MasterBox Q300L, with only Antec's P6 being warmer. The CPU delta T was, as expected, nothing to write home about either, with the mediocre front fan and lack of a rear fan adding a substantial 6°C to the temperature recorded with the Corsair Crystal Series 280X.

Conclusion

It's a shame that Thermaltake omitted a rear fan – it would have been much better to ditch the front 200mm fan and include front and rear 120mm fans instead.

As a result, the 200mm fan doesn't do a good job of directing its airflow at the CPU cooler or graphics card, and merely radiates airflow outwards in all directions. It also isn't particularly quiet, but that problem can easily be fixed in modern motherboard EFIs, and a half-decent rear fan will cost under a tenner

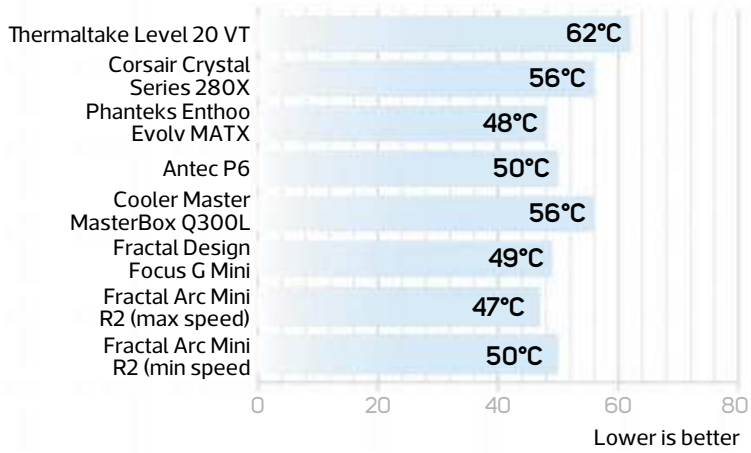
If you're planning on water-cooling your PC, though, the Thermaltake Level 20 VT is an excellent choice for the money, as it has the potential to cool an overclocked, high-end desktop system with two high-end graphics cards in a small space.

The tool-free storage mounts are also great, as is the ease of installation, and generous CPU heatsink and graphics card clearances. Despite its shortcomings, the Level 20 VT is an attractive micro-ATX cube case with a reasonable price – it will be fine for water-cooled systems, and you'll only need to fit a rear exhaust fan for air-cooled systems.

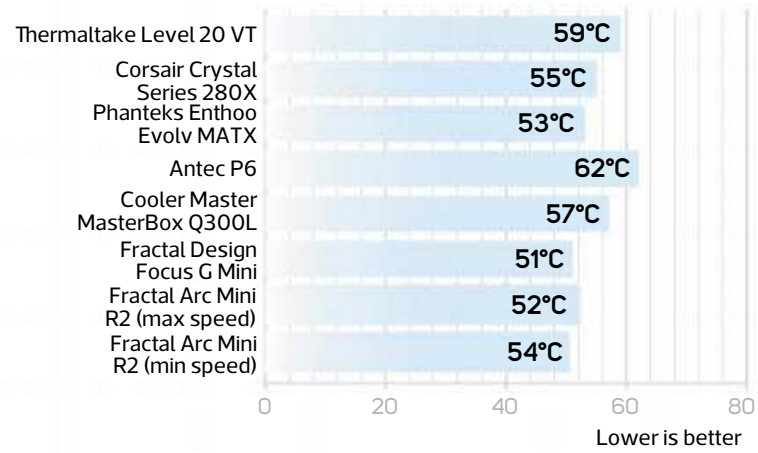
ANTONY LEATHER

TEMPERATURE RESULTS

CPU LOAD DELTA T



GPU LOAD DELTA T



COOLING	FEATURES
21/30	17/20
DESIGN	**VALUE**
27/30	18/20

OVERALL SCORE
83%

VERDICT

An attractive, capable micro-ATX cube case with tool-free storage bays and huge water-cooling potential, but the lack of a rear fan hurts its cooling out of the box.

PORTABLE THUNDERBOLT 3 SSD

Samsung Portable SSD X5 1TB / £630 inc VAT

SUPPLIER www.scan.co.uk

USB Type-C is a great connector, but it's a bit confusing as an interface standard, coming in USB 3.1 and Thunderbolt 3 flavours. Of the two, the latter can reach 40Mb/sec while USB 3.1 is capped at 10Mb/sec. And such speeds, as the Samsung Portable SSD X5 amply demonstrates, are particularly useful for external SSD drives, enabling you to take full advantage of a PCI-E NVMe SSD.

Samsung has history here, with its SSD T5 reigning supreme as the USB 3.1 speed king. With the SSD X5, it adds a Thunderbolt 3 to the mix, in your choice of 500GB, 1TB or 2TB capacities. Samsung quotes sequential read and write speeds of up to 2,800MB/sec and 2,300MB/sec respectively, which is around four or five times faster than the T5. That read speeds translates into 22.4Mb/sec, so the drive is clearly taking advantage of the Thunderbolt bus over USB 3.1 too.

Our tests show that these figures aren't far off the mark either. Testing with a Thunderbolt 3-equipped 2017 5K Apple iMac, the drive managed read and write speeds of 2,352MB/sec and 1,682MB/sec respectively. That's a huge improvement over the 500MB/sec and 480MB/sec speeds we saw from the T5. These results were also noticeably faster than the iMac's built-in NVMe SSD, which managed still respectable speeds of 1,058MB/sec and 756MB/sec.

The Samsung X5 managed read speeds of 2,352MB/sec

We then plugged the drive into a Dell XPS 15 Windows laptop, and yielded sequential read and write speeds of 2,057MB/sec and 1,531MB/sec. Not only that, but the drive continues to perform well when reading and writing non-sequential, smaller files, with respective speeds of 318MB/sec and 280MB/sec. By comparison, the non-Thunderbolt 3 Samsung T5 SSD only manages around 110-180MB/sec in the same test.

In terms of physical design, the X5 is available in one colour combo: a glossy silver front and a red enclosure around the back. It isn't much bigger than a modern smartphone; at 62 x 119 x 19.7mm (W x D x H), it's just twice the thickness. Even so, at 150g, you can easily pocket the drive. There's a single Thunderbolt 3 port with an LED showing when it's in use and Samsung bundles a Thunderbolt 3 cable, but no carrying case and sadly no waterproofing either.

Also note that you can't plug the X5 into a non-Thunderbolt 3 port. Even if you have the latest computer with USB 3.1 Type-C ports, the drive simply won't power on. That's because NVMe drives require a connection to the computer's PCI-E bus – and that can't happen through the regular USB interface.

Then we come to the price you have to pay. As you can imagine, it's not going to be cheap. Prices start at £360 inc VAT for the 500GB model, while the 1TB model we're reviewing here costs £630 inc VAT. If you need more space, Samsung also offers the 2TB X5, which costs a whopping £1,250 inc VAT.

Such prices are partly a result of the new technology, but also because Samsung effectively has a monopoly here. At the time of writing, there are no other 1TB Thunderbolt 3 NVMe external SSDs – the X5 is in a league of its own. The nearest equivalent is buying an external Thunderbolt 3 enclosure for around £300 inc VAT and then fitting it with a 1TB NVMe SSD for around £325 inc VAT, bringing the price within spitting distance of the Samsung X5's price anyway. Besides, doing it yourself would mean missing out on Samsung's handy Portable SSD software, which allows you to check for firmware updates and protect the drive with a password – the drive offers AES 256-bit hardware encryption too.

Conclusion

The Samsung X5 is expensive, can't be used with non-Thunderbolt 3 computers and isn't waterproof either. For most people's needs, a cheaper USB 3.1 drive such as the Samsung T5 (£296 inc VAT for 1TB) will suffice for transferring your everyday files. If you really want the fastest portable SSD, though, the X5 is incredibly quick. It's just a shame the price is so high.

CHRISTOPHER MINASIANS

PERFORMANCE	FEATURES	VALUE
50/50	16/20	12/30

OVERALL SCORE **78%**

VERDICT

Undeniably fast, Samsung's new X5 SSD replaces the company's trusty T5 as the king of portable drives, but it isn't cheap.

From Apple to Zeiss, and everything in between

Try these magazines from just £1:

magazinedeals.co.uk/tech

Whether you're an IT professional or a first time buyer, Dennis technology has a magazine for you, all of which are written and produced by expert editorial teams. We cover the whole spectrum of technology news, reviews and features.

32IN 4K MONITOR

ViewSonic VP3268-4K / £883 inc VAT

SUPPLIER www.cclonline.com

When you can buy a 32in, 4K monitor for under £500, you might wonder how ViewSonic has the audacity to charge £883 inc VAT for the VP3268-4K. The answer is accuracy. It offers a pre-calibrated IPS display that – ViewSonic claims – can reproduce 100 per cent of the sRGB spectrum.

When switching from the default mode to sRGB mode, the most obvious change isn't a sudden improvement in colour accuracy but that the VP3268-4K's display becomes dimmer. That's because the panel's sRGB calibration was performed at 120cd/m^2, and if you vary from this figure then your results will change. Once you select sRGB mode, you're locked to 120cd/m^2.

Fortunately, it performed magnificently in this mode. We measured an average delta E of 0.51, which edges towards perfection and overdelivers on ViewSonic's promise of a delta E under two. Its gamma tracking and uniformity are terrific too – its brightness typically deviated by under 5 per cent, with only the corners going up to 8 per cent. The only black mark was our calibrator reporting that it could only display 93.8 per cent of the sRGB gamut – not the 100 per cent ViewSonic claims. That's not overly concerning though - the more important figure is that low delta E.

Its gamma tracking and uniformity proved terrific

While 120cd/m^2 is fine, though, it seems a shame not to take advantage of the VP3268-4K's 357cd/m^2 peak brightness. Fortunately, the OSD allows you to jump quickly between colour modes, and we used the Standard Color setting in usual everyday use. Even then, though, and with the brightness boosted to 170cd/m^2, colour accuracy is strong. The average delta E increased to 1.52, and the gamma tracking grew notably worse, but our colorimeter reported that it covered 98.4 per cent of the sRGB gamut.

All this fiddling highlights a weak point though – its advanced OSD controls. There's no rotary button, so you have to flick left and right through the main headings – such as Input Select, Viewing Mode and Colour Adjustments – select which one you want, scroll down using a different button, then select the precise option you want to change and change it. It's awkward. The only consolation is that ViewSonic provides a much simpler set of controls for main shortcuts, such as controlling brightness and flicking between colour modes, so you can often avoid the main menu.

There are decent options tucked away too. With four inputs – two HDMI, one DisplayPort and one mini-DisplayPort – you can split the screen four ways and view all of them at once. ViewSonic builds in a generous four USB ports, plus an audio in and audio out if the built-in speaker doesn't offer quite enough power for you. Naturally, it can't match the quality of dedicated speakers, but it was fine for Skype calls and surprisingly effective when watching films.

There's an HDR mode too, with the 8-bit RGB IPS panel using frame rate control to gain higher colour accuracy and support HDR10 content. It isn't certified for content creation, but it works well in HDR films. Also, while the VP3268 isn't marketed as a gaming monitor, and doesn't support active sync or high refresh rates, it handles games remarkably well. Don't be put off by that 14ms response time either; a pixel overdrive setting in the OSD helps to reduce any (already minimal) ghosting.

Even the physical design is good. The slim bezels add to the display's already svelte style, and there's a pivot mode, 130mm of height adjustment and a well-designed base that makes it easy to swivel the screen 60 degrees each way.

Conclusion

While the ViewSonic doesn't have all the HDR features of pricier monitors, it offers excellent quality for the price. Sure, you'll have to either invest in a £100 hardware calibrator to make sure it stays accurate over time, but even then, the price is well below the competition in this segment from the likes of Asus and Eizo. If colour accuracy is your top priority, it's a great buy.

TIM DANTON

/SPECIFICATIONS

Panel type IPS
Native resolution 3,840 x 2,160
Diagonal 31.5in
Maximum refresh rate 60Hz
Active sync No
Display inputs 2 x HDMI 2 (with HDCP 2.2), DisplayPort 1.2, mini-DisplayPort
HDR support 8-bit panel with A-FRC, HDR10
Extras 2 x 5W speakers, 4 x USB 3 ports

IMAGE QUALITY	FEATURES	VALUE
52/55	10/15	23/30

OVERALL SCORE 85%

VERDICT

Brilliant colour accuracy when you need it and a bright, versatile 32in monitor when you don't – a great buy for colour purists.

buyacar.co.uk

The easiest way to buy your next car

Skip the forecourt - great deals from the comfort of your home

With over 40,000 new and used cars to choose from across the country, **buyacar.co.uk** makes it simple to find the car you want and will deliver it straight to your door.

Zero hassle
Choose from thousands of cars, apply for finance online with us and value your existing car - all from the comfort of your home.

The very best prices
Whether buying outright or taking one of our affordable monthly payment plans, we've travelled the UK for the best deals - so you don't have to.

Peace of mind
All our cars come from UK main dealers and go through rigorous checks and tests before they arrive at your door.

All cars come with a 14-day money-back guarantee

Find out more at buyacar.co.uk

100% would recommend!
All members of staff are lovely and willing to help.
SHANNON

Pleased with service
The process of getting the car was very easy and secure.
DANIEL

Easy Peasy!
No trawling garage showrooms! Already recommending to friends & family.
KAREN

Purchased VW Golf
I was nervous about buying on the internet. Needn't have worried.
SIMON

READ MORE REVIEWS ON TRUSTPILOT

HOW WE TEST
PAGE 42

27IN GAMING MONITOR

MSI Optix MPG27C / £399 inc VAT

SUPPLIER www.ebuyer.com

It may seem counter-productive to spend £399 on a 1080p monitor, but the Optix MPG27C makes up for its paucity of pixels with plenty of features, including rapid response times and refresh rates, innovative software and loads of RGB LEDs. The 1ms response time and 144Hz refresh rate are great for fast-paced gaming, and the high refresh rate worked well in our tests.

You also get FreeSync support, which runs from 48Hz to the monitor's maximum 144Hz refresh rate. AMD's current GPUs are unlikely to consistently hit that top figure in demanding titles, but the lower figure should be fine with a decent AMD GPU. FreeSync does limit you to AMD GPUs, but it also keeps the price down – a G-Sync equivalent of this screen would be much more expensive.

The black level is fantastic, creating a huge contrast ratio

Thankfully, the 1080p resolution also helps to make high frame rates a more realistic proposition, especially in esports titles, although the 27in diagonal means the image isn't particularly sharp at this resolution. On the plus side, you get a curved panel with an 1800R radius, which works well for wrapping gameplay around the player. The bezels are slim enough for multi-monitor too, and the 8-bit VA panel is solid – 8-bit is fine for gaming, and most gaming panels use VA for their great contrast and black levels.

On the outside, the MSI offers typical gaming aesthetics. It has wide, pointed feet, metallic accents and a multi-textured rear. There's a cable-routing hole too, and build quality is good. There's also tilt, swivel and height adjustment, and a VESA mount, but no portrait mode. It doesn't have speakers, but that isn't a huge issue– most gamers will use headsets or dedicated speakers anyway. Meanwhile, inputs come from a DisplayPort 1.2 socket and two HDMI 1.4 ports. It has side-mounted USB ports too, although they're only USB 2.

Disappointingly, the OSD control joystick is flimsy and awkward to use, but thankfully, MSI has put all of the OSD options into a Windows app, which makes it far easier to use. You get all the usual screen alteration options, tools to add reticules and the chance to bind common options to the keyboard. There's an Android app with most of these settings too.

Meanwhile, five bars of light at the bottom are illuminated with RGB LEDs, as is the logo at the rear. The SteelSeries Engine 3 app manages the lights, and they can flash with basic patterns or static colours. SteelSeries promises neat gaming interaction, but its GameSense system only works in a handful of games. There's CS:GO, DOTA 2 and Minecraft, but little else.

In terms of performance, the Optix is a typical gaming screen. The brightness level of 261cd/m^2 exceeds the quoted 250cd/m^2 figure, and the black level of 0.06cd/m^2 is fantastic, creating a huge contrast ratio that also exceeds MSI's figure. Darker areas in games appear particularly gloomy. That contrast ratio creates great punch throughout the rest of the screen's range. Whatever game you're playing, it will leap out of this screen.

Colour accuracy is average though. The delta E of 2.98 is middling, and the colour temperature of 7,420K is too cold, so the screen has a chilly cast. The 97.8 per cent sRGB coverage is good, at least, and the screen has reasonable uniformity, with a peak backlight variance of 12 per cent. We also measured an average response time of 10.6ms, which is easily fast enough for esports.

Conclusion

The Optix MPG27C doesn't have great colours, but that's less important on a screen designed for esports and fast-paced gaming, and in this respect, it offers huge contrast, deep black levels, a high refresh rate and rapid response times. MSI's software OSD is great too. The Optix performs where it counts, and it's cheaper than most rivals. The only limitation is FreeSync on such a high refresh rate display, as AMD doesn't have much in the way of high-end GPUs.

MIKE JENNINGS

/ SPECIFICATIONS

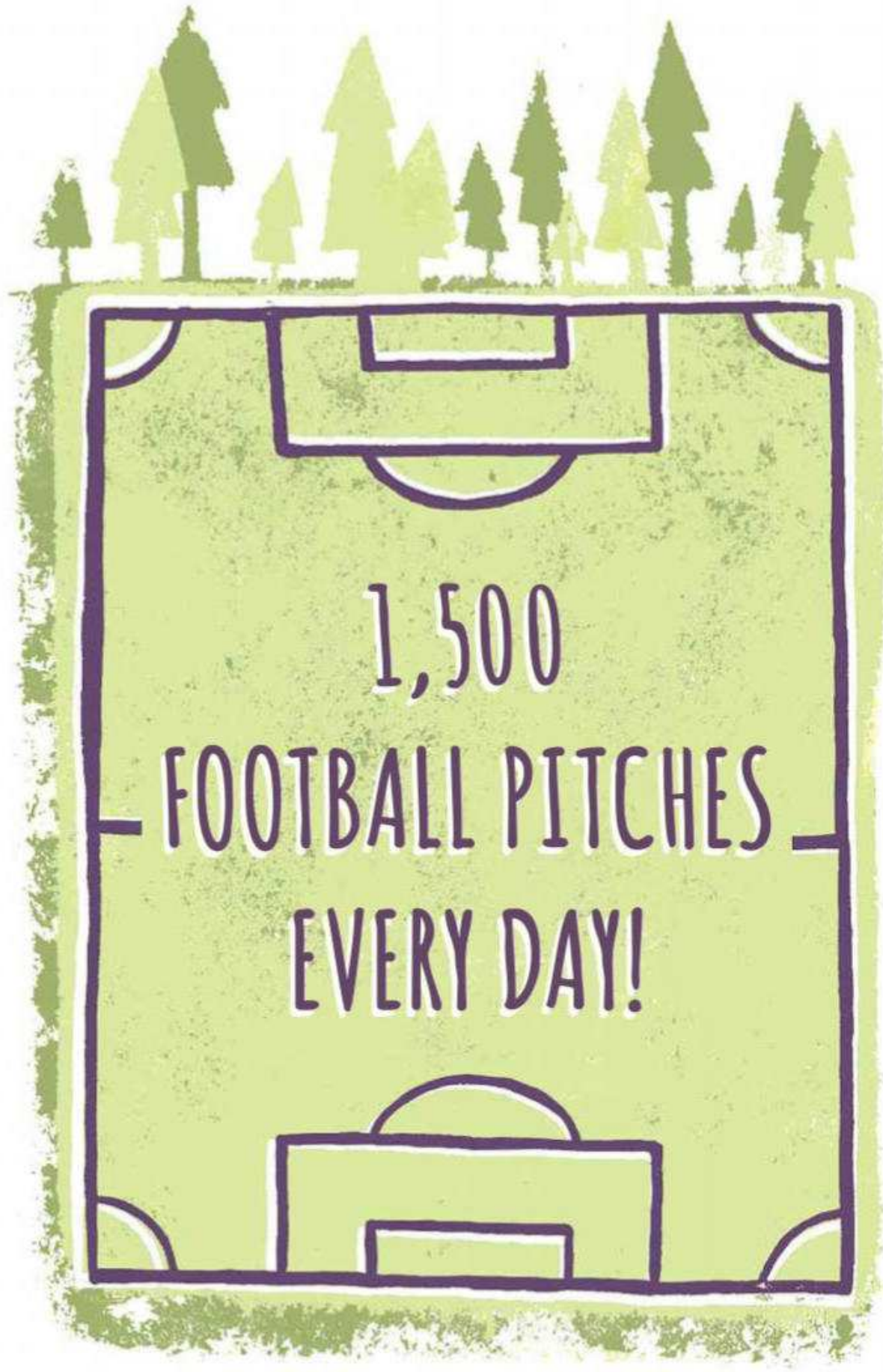
Panel type VA
Native resolution 1,920 x 1,080
Diagonal 27in
Maximum refresh rate 144Hz
Active sync AMD FreeSync
Display inputs 2 x HDMI 1.4, DisplayPort 1.2
Extras 2 x USB 2, 2 x audio jacks

IMAGE QUALITY	FEATURES	VALUE
46/55	13/15	25/30

OVERALL SCORE **84%**

VERDICT

Great contrast, software and features for a good price, although you'll need an AMD GPU to use FreeSync.



Did you know that European forests, which provide wood for making paper and many other products, have been growing by over 1,500 football pitches every day!

Love magazines? You'll love them even more knowing they're made from natural, renewable and recyclable wood.

UNFAO, Global Forest Resources Assessment 2005-2015

Two Sides is a global initiative promoting the responsible use of print and paper which, when sourced from certified or sustainably managed forests, is a uniquely powerful and natural communications medium.

There are some great reasons to #LovePaper
Discover them now,
twosides.info

TWO SIDES

Custom kit

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

Pocket Spinner Multi-tool / **£19.99** inc VAT

On some level it's possible to think that attaching an array of tools to a heavy-duty fidget spinner is such a bizarre idea that it just has to work. On every other level, and we're talking about many levels, the situation is less optimistic. As a tool, the Pocket Spinner includes an array of screwdrivers, which is fine, except there are many reasons why screwdrivers are their standard shape – a prime one being that you don't want lots of spiky bits digging into your hand.

As a spinner, the Pocket Spinner is also undermined by the fact that it has tools poking out of it. It's not especially unsafe; you'd have to be walking around in the first ten minutes of an episode of Casualty to do serious accidental harm with it, but it doesn't spin well and we've never used a more uncomfortable screwdriver. It's only redeemed slightly as a conversation starter, as long as you're happy for your conversations to start with, 'Why?'

●○○○○

SUPPLIER www.firebox.co.uk

KKmoon Delux T9 / **£30.99** inc VAT

Being a compact and cut-down version of what gamers generally consider the business end of a keyboard, the KKmoon Delux T9 is an attempt to streamline keyboard controls. The result is a rather mixed bag. The T9 does conveniently mash loads of the most frequently used keys for games into a comfortable-to-use, one-handed device, but the different layout requires a degree of retraining to use it effectively. To get the best out of the T9, you're looking at rebinding keys, relearning where your favourite keys are located and acclimating yourself to a new way of playing. Having learned your way around it, you can then easily hit keys that might have been out of reach of one hand beforehand, while freeing up your other hand completely for the mouse. The advantages are dubious, though, as you're still playing on a keyboard, just a smaller, more crowded one.

●●●○○

SUPPLIER www.amazon.co.uk

Dodow Sleep Light / **£44.99** inc VAT

The Dodow is a light designed to help people with insomnia or anxiety get a good night's sleep. It works by projecting a shape onto the ceiling of the room – you match your breathing to the shape as it expands and contracts and eventually you should fall asleep. The light has an eight-minute and a 20-minute program, and it switches off when it's finished. How well it works will vary from person to person, but its effect on this reviewer was soothing and helped to create a feeling of being ready for sleep.

However, the price of the Dodow means it's hard to recommend as a Plan A to deal with insomnia, especially as it's basically a light. There's a wealth of behaviour adjustments and smartphone apps that would be worth trying first, but the Dodow can create a relaxing, soothing effect if you're prepared to pay for it.

●●●○○

SUPPLIER www.firebox.co.uk

Sphero Mini / **£49.99** inc VAT

The Sphero Mini is a smartphone-controlled robot that's about the size and shape of a table tennis ball. The wisdom of such a device is immediately apparent to anybody who remembers Terrahawks. The Sphero Mini can be driven around your home using a variety of different interfaces on either an iOS or Android phone, and it provides a lot of fun.

The control software is well presented and offers a range of other activities, such as programmable behaviour, or you can use it as a controller for games, should you get bored of zooming it around the floor. The Sphero Mini is charged via USB and is good for around 45 minutes of play on a full charge.

It's a welcome change from the usual remote-controlled planes, trains and automobiles, and there's a range of accessories available, from replacement casings to tyres, ramps and chariots, so you're not limited to just playing with balls. A great toy for just under 50 quid.

●●●●●

SUPPLIER www.firebox.co.uk

iWalk Power Bank 12,000mAh / **£29.99** inc VAT

The iWalk is a well-designed lump of a power bank. Boasting a capacity of 12,000mAh (approximately six iPhone 8 recharges), the iWalk is fairly weighty and it's about the same size as a smartphone in a case. However, a combination of sleek, rounded corners and built-in cables recessed into gaps in the casing reduce the hassle of carrying the device considerably.

The activator button and charge level lights are low-key but clear, and you can charge the iWalk via micro-USB or USB-C, or with its built-in USB cable. Meanwhile, it will output its charge via micro-USB, USB-C and Lightning, although there's no outgoing USB plug for devices using proprietary connections. It's difficult, if not impossible, to get this much capacity into a portable power bank without making it a bit like a brick, but the iWalk does a fine job of mitigating the encumbrance – a brick for the connoisseur.

●●●●○

SUPPLIER www.amazon.co.uk

Nenrent Wireless Earbud S570 / **£14.99** inc VAT

The Nenrent Bluetooth S570 earbud offers a different approach to sound than most other headphones and similar devices, inasmuch as the sound isn't really the priority. Firstly, because these units are sold (and can operate) singularly, you're never going to get the sort of immersion you'd get from a pair of earbuds or headphones. Secondly, the Nenrent is very small and discreet, and is even available in a near approximation of skin colour, so it isn't immediately obvious you're using it.

The Nenrent earbud isn't capable of being particularly loud, and it doesn't impress with music, but it has enough clarity to allow you to listen to podcasts and audiobooks while you're walking, while keeping one ear free to listen for traffic and so on. If you have a pair of them, you can also effectively listen to two different audio sources at the same time. The battery gives you around five hours of listening before it needs a recharge, for which it uses a USB adaptor with a narrow probe. Don't expect the Nenrent Wireless Earbud S570 to shake your musical world, but it does its job as a one-ear spoken-word companion fine.

●●●○○

SUPPLIER www.amazon.co.uk

Seen something worthy of appearing in Custom Kit? Send your suggestions to editor@custompcmag.org.uk

PC Specialist recommends Windows Windows 10

RECOIL II PRO

15.6" Matte Full HD Screen
Intel® Core™ i7-8750H
16GB Corsair 2400MHz
6GB GeForce GTX 1060
1TB SEAGATE 7mm SATA HDD (5,400)
Genuine Windows 10 Home

This spec from
£1,249.99

THE VORTEX 3500

COOLERMASTER COSMOS C700P
Intel® Core™ i9-7900X
Gigabyte X299 UD4 PRO
32GB Corsair VENGEANCE RGB 3000MHz
11GB GEFORCE RTX 2080 Ti
Genuine Windows 10 Home

This spec from
£3,519.99

VYPER PRO

15.6" Matte Full HD Screen
Intel® Core™ i7-8750H
8GB Corsair 2133MHz
4GB GeForce GTX 1050 Ti
1TB SEAGATE 7mm SATA HDD (5,400)
Genuine Windows 10 Home

This spec from
£829.99

THE FUSION 1900

CORSAIR CRYSTAL 460X RGB
AMD Ryzen 7 2700X
Gigabyte X470 AORUS Ultra Gaming
16GB Corsair VENGEANCE 2400MHz
8GB GEFORCE RTX 2080
Genuine Windows 10 Home

This spec from
£1,879.99

GET A FURTHER £15 OFF WITH THIS EXCLUSIVE VOUCHER CODE: **CPC18**

0333 011 7000

Some features require Windows 10. Update available through Windows Store. Internet access required; fees may apply.
Microsoft, and Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

* Prices are including VAT and are correct at the time of printing, but subject to change.

/PCSPECIALIST @PCSPECIALIST

pcspecialist

CUSTOM GAMING DESKTOPS & LAPTOPS

ORDER ONLINE NOW AT

WWW.PCSPECIALIST.CO.UK

How we test

PROCESSORS

INTEL LGA1151-V2


Intel LGA1151-V2 CPU


Asus ROG Strix Z370-E Gaming


16GB Corsair Vengeance LED 3000MHz DDR4


480GB Crucial MX500


Zotac GeForce GTX 1080 AMP! Edition

INTEL LGA2066


Intel LGA2066 CPU


Asus ROG Strix X299-E Gaming


32GB Corsair Vengeance LED 3000MHz DDR4


256GB Crucial MX100


Zotac GeForce GTX 1080 AMP! Edition

AMD AM4


AMD AM4 CPU


MSI X470 Gaming M7 AC


16GB Corsair Vengeance LED 3000MHz DDR4


256GB Crucial MX100


Zotac GeForce GTX 1080 AMP! Edition

AMD AM4 (APU)


AMD APU


MSI B350I Pro AC


16GB Corsair Vengeance LED 3000MHz DDR4


256GB Crucial MX100

Radeon RX Vega integrated GPU

AMD TR4


AMD TR4 CPU


MSI MEG X399 Creation


32GB Corsair 3000MHz Vengeance LED DDR4


256GB Crucial MX100


Zotac GeForce GTX 1080 AMP! Edition

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

GRAPHICS CARDS

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


4.7GHz Intel Core i7-8700K


16GB Corsair 3000MHz Vengeance LED DDR4


Gigabyte Z370 Aorus Gaming 5


Windows 10 64-bit

The graphics card we're reviewing

CUSTOM PC REALBENCH

INTEL REFERENCE

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

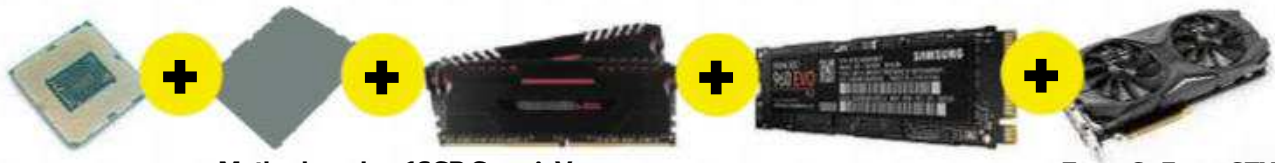
AMD REFERENCE

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

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

MOTHERBOARDS

INTEL LGA1151-V2

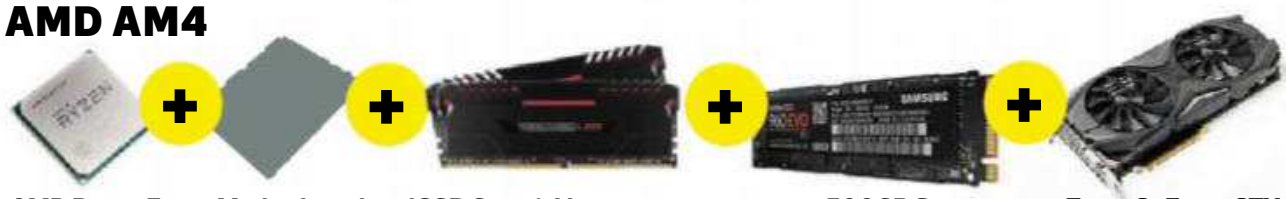


Intel Core i7-8700K | Motherboard on test | 16GB Corsair Vengeance LED 3000MHz DDR4 | 500GB Samsung SSD 960 Evo | Zotac GeForce GTX 1080 AMP! Edition

INTEL LGA2066

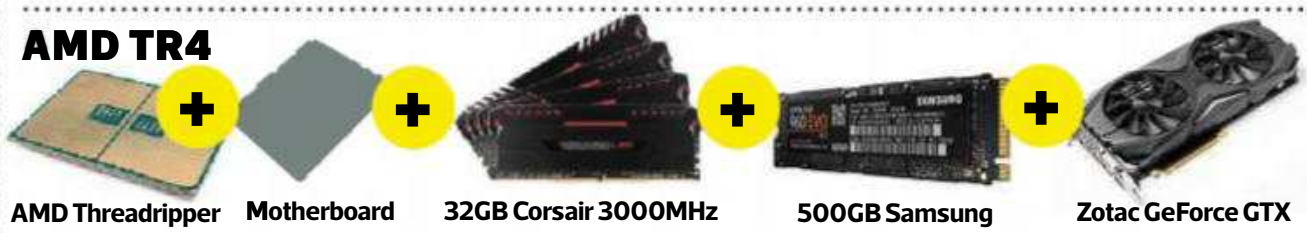
Intel Core i9-7900X | Motherboard on test | 32GB Corsair Vengeance LED 3000MHz DDR4 | 256GB Crucial MX100 SSD | 500GB Samsung SSD 960 Evo | 2 x Asus Strix Radeon RX 480 8GB

AMD AM4



AMD Ryzen 7 2700X | Motherboard on test | 16GB Corsair Vengeance LED 3000MHz DDR4 | 500GB Samsung SSD 960 Evo | Zotac GeForce GTX 1080 AMP! Edition

AMD TR4



AMD Threadripper 2950X | Motherboard on test | 32GB Corsair 3000MHz Vengeance LED DDR4 | 500GB Samsung SSD 960 Evo | Zotac GeForce GTX 1080 AMP! Edition

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

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 Shadow of the Tomb Raider, Total War: Warhammer II, Deus Ex: Mankind Divided and Doom 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.

SUBSCRIBE NOW!

Subscribe to **CUSTOM PC** today and save on the single issue price.

Each issue of ***Custom PC*** will be delivered directly to your device each month.

SEE NEXT PAGE FOR SET-UP INSTRUCTIONS

HOW TO SUBSCRIBE...

...on an iPad or iPhone

STEP 1 Return to the *Custom PC* library

STEP 2 Choose your subscription term and tap twice on the 'price' box

STEP 3 Choose whether to create an optional PixelMags account

STEP 4 Enter your Apple ID password to confirm

Download on the App Store

...on a Kindle Fire

Kindle Fire subscriptions come with a FREE one month trial.

STEP 1 Tap 'Free Trial Subscription' in the *Custom PC* library

STEP 2 Chose your subscription term from the drop down menu on the popup that appears

STEP 3 Tap 'Subscribe'

available on kindle fire

...on an Android device

STEP 1 Open the Google Play Store homepage and navigate to the Newsstand section using the tabs at the top

STEP 2 Search for *Custom PC* using the search icon in the top right of the screen

STEP 3 Click the 'Subscribe' button and pick your term

STEP 4 Enter your Google password to confirm

android

...via the Zinio app

STEP 1 Search for *Custom PC* via the search box in the Shop tab

STEP 2 Tap the 'Subscribe' button

STEP 3 Choose whether to create an optional Zinio account

STEP 4 Enter your Apple ID password to confirm

Subscribe to *Custom PC* today and save on the single issue price

LABS TEST

Liquid lunch

Antony Leather puts eight of the latest 240mm all-in-one liquid coolers through their paces on Intel and AMD sockets

Contents

Alphacool Eisbaer LT 240 / p47
Cooler Master MasterLiquid ML240R RGB / p48
Corsair H100i RGB Pro / p50
Deepcool Castle 240 / p51
EK Water Blocks Phoenix 240 / p52
Fractal Design Celsius 24 / p53
Game Max Iceberg 240mm / p54
NZXT Kraken X52 / p55
Results graphs / p56

How we test

When testing CPU coolers, we want to examine performance across a range of sockets, as the mounting mechanisms vary between them; some coolers perform well on some CPU sockets, but not on others. For this reason, we test across three sockets and we've updated our Intel test rigs this month, using CPUs without soldered heatspreaders.

Our LGA1151 test rig comprises an MSI Z370 PC Pro and Intel Core i5-8600K overclocked to 4.6GHz with a 1.2V vcore. Next is LGA2066 using an MSI X299M Gaming Pro Carbon AC and Intel Core i9-7900X overclocked to 4.2GHz with a 1.15V vcore. Finally, our Socket AM4 rig uses an Asus ROG Strix B350-F Gaming and AMD Ryzen 7 1700 overclocked to 3.9GHz with a 1.425V vcore.

We also use 16GB of 3000MHz Corsair Vengeance LPX memory along with a Crucial MX100 SSD and a be quiet! System Power 9 500W PSU. Our test systems are housed in a Fractal Design Meshify C case and we use Windows 10.

We use CoreTemp to measure the CPU temperature, before subtracting the ambient air temperature to give a delta T result, which enables us to test in a lab that isn't temperature controlled. We use Prime95 version 26.6's smallfft test to load the CPU and take the reading after ten minutes. We also take sound readings from a distance of 30cm, with the fans and pumps at full speed, to assess the maximum noise.

To obtain a final score, we apply a weighted calculation to the cooling, design, features and value scores. There's a separate score for each CPU socket, accounting for the different cooling and mounting mechanisms as well as value. The feature score includes aspects such as software control, lighting, expansion possibilities and PWM fans; the design score considers installation, noise and aesthetics; and the value score takes all the results into account as well as the price.

Alphacool Eisbaer LT 240 / £82 inc VAT

SUPPLIER www.aquatuning.co.uk

LGA1151

As the bigger sibling of the recently Premium Grade-awarded Eisbaer LT 120, we really wanted to see how the Eisbaer LT 240 fared against the other 240mm all-in-one liquid coolers available. Like its smaller sibling, it's an expandable cooler, with a quick-release fitting plumbed into the middle of one of the coolant tubes.

This fitting enables you to add other parts, such as reservoirs or GPU waterblocks, without draining the system. The company's range of Eiswolf GPX Pro GPU waterblocks come pre-filled too, so you can connect them straight to the Eisbaer LT 240. Meanwhile, the radiator is made from copper, so it should perform better than aluminium radiators, as well as eliminating the risks involved with mixing metals. You can add any other copper-based components to your loop too.

In terms of pricing, the Eisbaer is £20 cheaper than the likes of the Corsair H100i Pro RGB, but despite its expandability, it's fairly basic in terms of other features. For example, there's no lighting or other fancy aesthetic touches. There's no software control with the PWM fans either, which operate between 550-1,700rpm, and need to be hooked up to your motherboard. Thankfully, Alphacool includes a splitter cable, so you only need two headers to power both the pump and fans.

On the plus side, the pump was fairly quiet at full speed and can be throttled using your motherboard or resistor cables too, so the Eisbaer LT 240 can be fine-tuned into a very quiet cooler indeed at low loads.

The mounting mechanism is also fairly archaic compared with other coolers on test, with nearly 20 parts needed to mount the pump to your motherboard. It works well and offers a solid mount, although it's likely you'll need to remove the motherboard from your case to fit it. There are no screws to mount additional fans either, but these screws are available for a small fee on Aquatuning's website. Out of the box, you can mount the fans in push or pull mode and with the radiator or fans mounted to the case.

The Eisbaer LT 240's most competitive performance was seen in our LGA1151 test system, where it was just 3°C warmer than the best results. However, it wasn't quite as competitive in our LGA2066 and Socket AM4 systems, lagging behind by 8°C and 7°C respectively compared with the top-performing EK Water Blocks Phoenix 240.

Conclusion

Faced with a barrage of competition, the Alphacool Eisbaer LT 240 is still a good choice for all three CPU sockets we tested this month, although there are better options for LGA2066 and AMD's Socket AM4. Corsair's H100i Pro RGB is much easier to fit on AM4 and offers better cooling, while costing just £18 more, while the Game Max Iceberg 240mm costs £30 less and did a similar job in dealing with our overclocked Core i9-7900X, albeit with a little more noise.

However, when coupled with a motherboard that can fine-tune the Eisbaer LT 240's pump and fans, it's a great choice for LGA1151 CPUs, and is especially worth considering if expandability is more important to you than lighting or fan control software.

VERDICT

A good effort all round, especially for LGA1151 CPUs, with the bonus of expandability. However, you can get more features and better AM4 cooling elsewhere.

/SPECIFICATIONS

Compatibility Intel: LGA2066, LGA2011/v3, LGA1366, LGA115x; AMD: Socket AM4, AM3/+, AM2/+, FM2/+, FM1

Radiator size with fans (mm) 120 x 270 x 50 (W x D x H)

Fans 2 x 120mm

Stated noise 29dBA

LGA1151 RESULTS

COOLING	FEATURES	OVERALL SCORE
36/40	14/20	86%
DESIGN	VALUE	
17/20	19/20	
FITTING		
MEDIUM		

LGA2066 RESULTS

COOLING	FEATURES	OVERALL SCORE
33/40	14/20	83%
DESIGN	VALUE	
19/20	17/20	
FITTING		
MEDIUM		

AM4 RESULTS

COOLING	FEATURES	OVERALL SCORE
32/40	14/20	78%
DESIGN	VALUE	
17/20	15/20	
FITTING		
MEDIUM		

Cooler Master MasterLiquid ML240R RGB / £100 incVAT

SUPPLIER www.scan.co.uk

Cooler Master's MasterLiquid ML240R RGB won an Approved award earlier this year, but it now needs to try its hand against the other new kids on the block. It goes big on RGB lighting. There's a SATA-powered RGB controller in the box, with buttons to control the lighting colours and effects, and if you use an included USB cable, you can also use Cooler Master's own RGB LED controller software. Cooler Master claims the lighting is compatible with the major motherboard manufacturers' RGB software too.

The pump section is particularly bright and vivid, with individually controllable RGB LEDs that make for great rainbow effects, although Deepcool's Gamer Storm Castle 240 (see p51) looks even better in this respect. The downside to the lighting is that you have to deal with three extra cables, giving you half a dozen in total, which can result in a mess. You do get splitter cables for the fans and lighting spaghetti, though, and generous use of cable ties should get it all in order fairly quickly.

Installation on Socket AM4 is blissfully simple, thanks to Cooler Master making use of the standard two mounting brackets, with clips that secure to the cooler and are then tightened using thumbscrews.

This setup means you don't have to remove the stock AMD backplate, unlike most of the other coolers on test.

However, even in this case, you need to secure the clips using screws, while Corsair's AMD and Intel brackets simply clip into place with no tools needed. The small thumbscrews that Cooler Master uses on Intel sockets make installation even fiddlier, so it's just as well you'll only have to do it once.

In terms of performance, the MasterLiquid ML240R RGB was one of the quieter coolers on test at full speed, generating 54dBA at close range compared to 59dBA for the EK Water Blocks Phoenix 240 (see p52) and 56dBA for the Corsair H100i Pro RGB (see p50).

The Socket AM4 delta T of 48°C in our new overclocked test system was noticeably warmer than most of the competition, however. It fared better in our Intel systems, though, with a reasonable result when cooling our Core i9-7900X with a CPU delta T of 57°C, beating the Fractal Design Celsius 24 (see p53) and Alphacool Eisbaer LT 240 (see p47). The Cooler Master was only 3°C warmer than the top result in our LGA1151 system too, where there was very little difference between the top and bottom results.

Conclusion

The Cooler Master MasterLiquid ML240R RGB scored well on all three CPU sockets, but it was most at home on LGA2066. Apart from fiddly mounting mechanisms, though, the main problem is that it has stiff competition.

For example, the similarly priced Deepcool Gamer Storm Castle 240 performs similarly across the board, but has a slightly higher lighting wow factor. Meanwhile, Corsair's H100im RGB Pro costs the same price and offers better cooling, as well as some tweakable lighting and software control.

VERDICT

Still a good cooler, especially for LGA2066 CPUs, but there are similarly priced alternatives that offer better lighting or cooling for similar money.

/SPECIFICATIONS

Compatibility Intel: LGA775, LGA2011/v3, LGA2066, LGA115x, LGA1366; AMD: Socket AM4, AM3/+, AM2/+, FM2/+, FM1

Radiator size with fans (mm) 120 x 277 x 52 (W x D x H)

Fans 2 x 120mm

Stated noise Up to 30dBA

LGA1151 RESULTS

COOLING	FEATURES	OVERALL SCORE
36/40	14/20	79%
DESIGN	**VALUE**	
14/20	15/20	
FITTING		
MEDIUM		

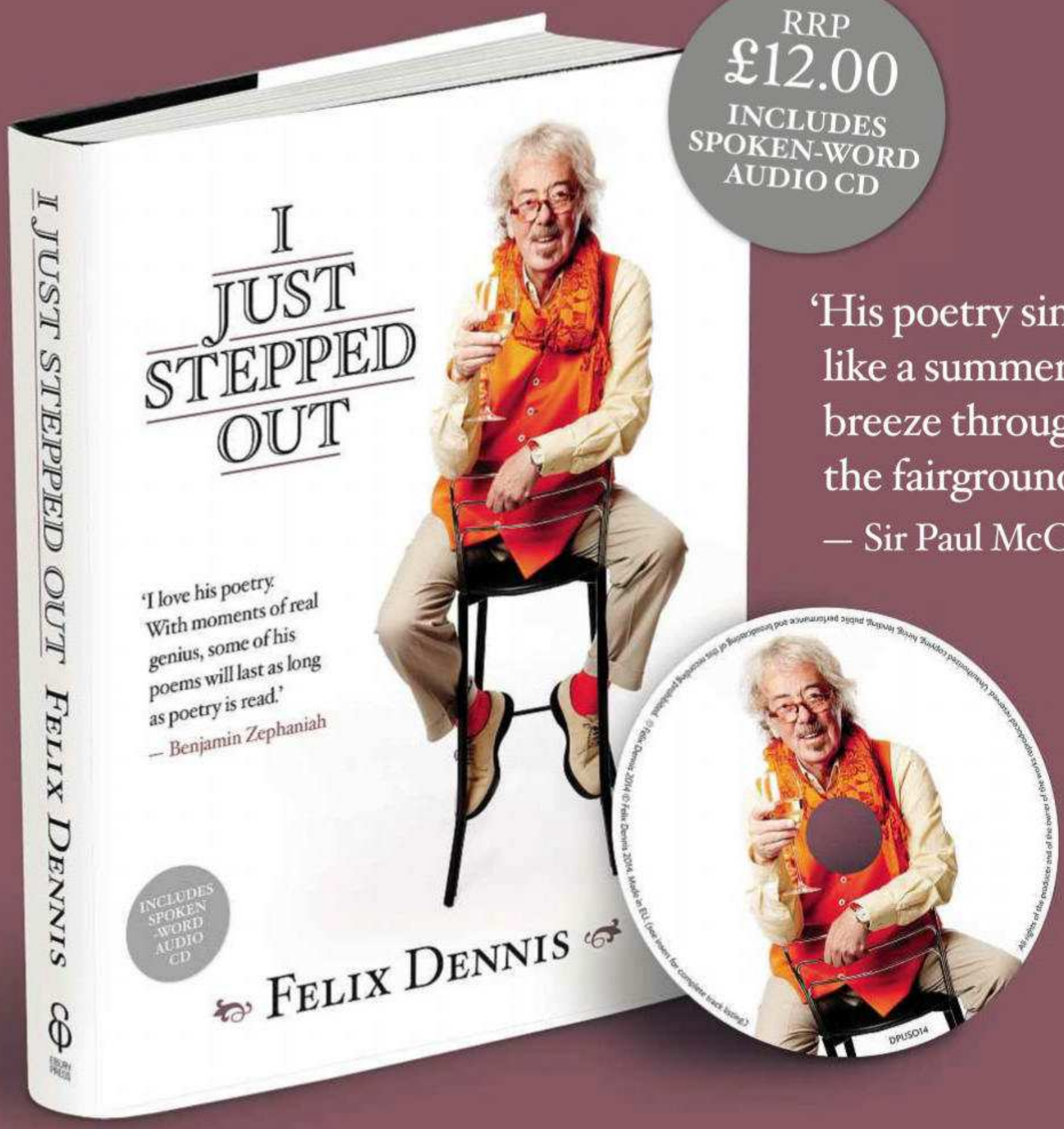
LGA2066 RESULTS

COOLING	FEATURES	OVERALL SCORE
34/40	14/20	84%
DESIGN	**VALUE**	
19/20	17/20	
FITTING		
EASY		

AM4 RESULTS

COOLING	FEATURES	OVERALL SCORE
32/40	14/20	78%
DESIGN	**VALUE**	
19/20	13/20	
FITTING		
EASY		

I JUST STEPPED OUT



RRP
£12.00
INCLUDES SPOKEN-WORD AUDIO CD

'His poetry sings like a summer breeze through the fairground.'
— Sir Paul McCartney

A startlingly honest and intense collection, I JUST STEPPED OUT is a kind of 'last will and testament' in verse. Written by Felix Dennis after his diagnosis with terminal cancer, these poems chart his physical, emotional and psychological journey.

Available now from Amazon and all good booksellers.

EBURY PRESS

For more information on Felix Dennis go to: **www.felixdennis.com**

Corsair H100i Pro RGB / **£100** inc VAT

SUPPLIER www.ebuyer.com

Corsair's revamped RGB coolers, namely the H115i Pro RGB and H150i Pro RGB, might be expensive, but they offer excellent cooling at low noise levels, as well as an exceptionally simple and easy-to-use mounting mechanism for both AMD and Intel sockets. The downside is that they require a large case with space for a 360mm or 280mm radiator. The H100i Pro RGB, though, has a more commonly sized 240mm radiator, which should fit in the majority of cases, along with its two ML-series fans.

These fans differ significantly to the spinners on the larger coolers, though, as they can spin at a super-fast speed of 2,400rpm. The 140mm fans on the H115i Pro RGB are limited to just 1,200rpm while the H115i Pro RGB's 120mm fans are capped at a comparatively paltry 1,600rpm. Basically, at full speed the H110i Pro RGB may well match much larger coolers, thanks to higher airflow, albeit at higher noise levels.

Meanwhile, the compact pump unit looks and feels well made, with a splash of RGB lighting on the logo and rings around it. The tubing is braided and flexible, and the simple mounting system made the H100i RGB Pro a pleasure to test compared with some of the other coolers this month. The mounting plates now twist into place from the bottom, leaving you to deal with just the socket pins and backplate on AM4 and LGA1151 sockets. Thankfully, the pins actually secure to the backplate first, so mounting the cooler doesn't involve holding the backplate too, unlike the Game Max Iceberg 240mm (see p54).

Corsair uses the pump to power the fans with a splitter cable, while a USB cable connects the pump to your motherboard to hook into Corsair's iCUE software. You can apply speed profiles to the pump and fans, but only the fans offer full customisation. By default, the cooler is set to respond to coolant temperature, which can lead to higher CPU temperatures and limit the fan speeds. As a result, we set the cooler to the Silent profile to get our low-speed result and manually set it to monitor the CPU temperature for the high-speed result, which saw the fans ramp up to full speed quickly under stress testing.

As we suspected, those beastly fans helped the H100i Pro RGB to compete against the mighty EK Water Blocks Phoenix 240's thermal performance, matching it in our overclocked Core i5-8600K LGA1151 system, although the EK Water Blocks unit was a few degrees cooler still in our AM4 and LGA2066 systems. Switching to the Silent profile saw the CPU delta T rise significantly in all our tests systems, with the H100i Pro RGB taking longer to respond to the heat load as the coolant warmed. However, its noise level measured 38dBA when our stress test finished, which is very quiet indeed.

Conclusion

With top-notch cooling and easy installation, the Corsair H100i Pro RGB gets an award on every CPU socket this month and it's a battle between against the NZXT Kraken X52 for the top spot each time. The Corsair's cheaper price gives it the edge, but they're both superb coolers.

VERDICT

A great cooler for all CPU sockets, and it's easy to install too.

/SPECIFICATIONS

Compatibility Intel: LGA775, LGA2011/v3, LGA2066, LGA115x; AMD: Socket AM4, AM3/+, AM2/+, FM2/+, FM1

Radiator size with fans (mm) 120 x 276 x 52 (W x D x H)

Fans 2 x 120mm

Stated noise Up to 37dBA

LGA1151 RESULTS

COOLING	FEATURES	OVERALL SCORE
38/40	17/20	92%
DESIGN	VALUE	
19/20	18/20	
FITTING		
EASY		

LGA2066 RESULTS

COOLING	FEATURES	OVERALL SCORE
36/40	17/20	90%
DESIGN	VALUE	
19/20	18/20	
FITTING		
EASY		

AM4 RESULTS

COOLING	FEATURES	OVERALL SCORE
36/40	17/20	87%
DESIGN	VALUE	
19/20	15/20	
FITTING		
EASY		

LGA1151

Deepcool Gamer Storm Castle 240 RGB / £96 incVAT

SUPPLIER www.scan.co.uk

Like many coolers on test this month, Deepcool's Gamer Storm Castle 240 RGB will set you back around £100 thanks to its extensive RGB lighting, although it can certainly lay claim to being the best-illuminated cooler this month. Both its fans and pump have individually controllable LEDs, which are punchy and vibrant, and have similar brightness levels, which can't be said of the Cooler Master MasterLiquid ML240R RGB (see p48). If RGB lighting is key to your build, the Gamer Storm Castle 240 RGB gets top marks.

The lighting can be controlled by Asus' Aura software, or an included SATA-powered remote control if your motherboard is made by a different company, and there are cables to attach additional devices too. Also included in the box is a 4-port PWM fan hub to power the two included fans and pump, but it can also power a case fan, which is a neat touch.

Installation is rather fiddly, though, especially on LGA115x sockets, which require a backplate with pins to be constructed and held in place while you mount the cooler using thumbscrews. All sockets need mounting plates to be screwed to this cooler's pump too; Corsair's H100i Pro RGB (see p50) is definitely much quicker and easier to install.

The Corsair cooler also has software control, which is missing here, as well as much more powerful fans; the two 120mm fans included with the Gamer Storm Castle 240 RGB are limited to a speed of 1,600rpm. However, the fan blades are translucent, which is likely why they look so good when they're illuminated, as they effectively diffuse the light from the RGB LEDs.

The pump section has a large brushed copper base plate, and its tubes can rotate in place to allow them to move while you're fitting the radiator. Sadly, only screws for a single row of fans are included. On the plus side, there's a generous amount of thermal paste included, which you'll need to apply first.

The slow-spinning fans didn't render the Gamer Storm Castle 240 RGB useless by any means, but they didn't sound much quieter than the fans on the Corsair and NZXT coolers, despite the latter ones spinning considerably faster. Still, it came within 3°C of the Corsair H100i Pro RGB in our LGA115x system where it faced our overclocked Core i5-8600K, and it was just 4°C warmer than the Corsair in our LGA2066 system too.

It also performed well in our AM4 system, managing a CPU delta T of 47°C compared to 43°C for the NZXT Kraken X52.

Conclusion

With superb lighting, a reasonable price and performance that isn't far off the best coolers on test, the Deepcool Gamer Storm Castle 240 RGB is a solid choice, handling all three of our overclocked CPUs well, including the monstrous Core i9-7900X. Both the Corsair H100i Pro RGB and NZXT Kraken X52 offer slightly better deals overall, with easier installation, lower temperatures and software control. However, if looks are a top priority, and you much prefer the Deepcool's RGB pizzazz to the competition, then it's still a decent option.

VERDICT

A fantastic-looking cooler with solid performance. There are better coolers in this price bracket, but the Deepcool is the one to buy if looks are a top priority.

/SPECIFICATIONS

Compatibility Intel: LGA2011/v3, LGA2066, LGA1366, LGA115x; AMD: Socket AM4, AM3/+, AM2/+, FM2/+, FM1

Radiator size with fans (mm) 120 x 274 x 52 (W x D x H)

Fans 2 x 120mm

Stated noise Up to 30dBA

LGA1151 RESULTS

COOLING	FEATURES	OVERALL SCORE
36/40	14/20	86%
DESIGN	VALUE	
19/20	17/20	
FITTING		
MEDIUM		

LGA2011 RESULTS

COOLING	FEATURES	OVERALL SCORE
34/40	14/20	85%
DESIGN	VALUE	
19/20	18/20	
FITTING		
MEDIUM		

AM4 RESULTS

COOLING	FEATURES	OVERALL SCORE
33/40	14/20	80%
DESIGN	VALUE	
19/20	14/20	
FITTING		
MEDIUM		

EK Water Blocks EK-MLC Phoenix 240 / £160 inc VAT

SUPPLIER www.overclockers.co.uk

The EK Water Blocks EK-MLC Phoenix 240 is really two different products that can be bought together to create a CPU-only water-cooling loop. There's the EL-MLC Phoenix CPU module, which has two versions available – one catering for AM4 and Intel sockets, while the other one caters for AMD's socket TR4. The other part is the EK-MLC Phoenix 240 radiator module, and both parts are pre-filled with coolant, connecting together with quick-release fittings. It's proper, expandable water-cooling gear, but there's no bleeding, filling or leaks involved, and connecting and detaching components takes seconds.

The radiator section has seen a price cut too, coming down to just over £110, meaning you can now get both parts for £160 inc VAT, which is just £40 more than the NZXT Kraken X52 (see p55). As the components are pre-filled and have quick-release fittings, you can add other components to the loop too. EK Water Blocks has a range of pre-filled GPU waterblocks, for example, which can be attached to your graphics card and simply connected to your existing loop. You can also expand the cooling with a larger radiator.

The radiator itself is where all the magic happens. It has a SATA-powered integrated pump and PWM hub, allowing your motherboard to control the fan speed. The fans are also pre-installed in pull mode, so if you mount them in the roof, you won't see them through your side panel. They can spin up to 2,200rpm too, so there's plenty of cooling power on tap.

As you can remove the radiator section, installing the waterblock section is incredibly easy, and a backplate is supplied that you secure using pins screwed in from the front side of the motherboard. The block then sits on these pins, secured by springs and thumbscrews, leaving you to install the radiator and then connect the tubes together. With the pump and fans controlled by the hub via your motherboard, there's then just a single power and fan cable to connect.

With the fans at full speed, it wasn't surprising to see the Phoenix 240 top the noise chart at 59dBA at close range. It also doesn't help that they're right next to the vent in our test case, spilling out noise into the room. However, the whole contraption is blissfully quiet at low and medium loads.

Despite having 200rpm slower fans, the EK-MLC Phoenix 240 managed to beat the Corsair H100i Pro RGB (see p50) by 2°C in our AM4 system and by 3°C in our LGA2066 system, meaning it's clearly able to deal with the heat produced by our overclocked Ryzen 7 1700 and Core i9-7900X. However, there was no difference between the two coolers in our LGA1151 system, with an overclocked Core i5-8600K at the helm.

Conclusion

While it offers excellent cooling, it's at low and medium loads that the EK-MLC Phoenix 240 really shines, offering extremely low noise. However, the competition has caught up now, as Corsair and NZXT's fans and pumps are also very quiet, leaving the EK-MLC Phoenix 240 with a big price tag and only marginally lower temperatures. However, if you plan to add other components, or if want an easy route into custom liquid cooling, the Phoenix is still a great choice and it offers unbeatable cooling for high-end desktop CPUs too.

VERDICT

Amazing performance, expandability and easy installation, but this expensive cooler is only really worth considering for overclocked high-end desktop CPUs.

/SPECIFICATIONS

Compatibility Intel: LGA2066, LGA2011/v3, LGA115x; AMD: Socket AM4

Radiator size (mm) 133 x 295 x 68 (W x D x H)

Fans 2 x 120mm

Stated noise Up to 33dBA

LGA1151 RESULTS

COOLING	FEATURES	OVERALL SCORE
38/40	15/20	82%
DESIGN	**VALUE**	
18/20	11/20	
FITTING		
EASY		

LGA2011 RESULTS

COOLING	FEATURES	OVERALL SCORE
39/40	15/20	84%
DESIGN	**VALUE**	
18/20	12/20	
FITTING		
EASY		

AM4 RESULTS

COOLING	FEATURES	OVERALL SCORE
38/40	15/20	85%
DESIGN	**VALUE**	
18/20	14/20	
FITTING		
EASY		

Fractal Design Celsius 24 / £100 inc VAT

SUPPLIER www.overclockers.co.uk

As the reigning 240mm liquid cooler on our Elite list, the Fractal Design Celsius 24 takes its place against the rest of the field this month having not been toppled for over a year.

However, it's already looking dicey, since it still costs around £100 yet lacks software control, RGB lighting and the expansion possibilities offered by competitors this month in various forms.

However, it still has plenty going for it. It has a radiator-mounted PWM fan hub, and the cable is cleverly routed up to this hub from the pump inside the tube braid. As the fans can also be plugged into the hub, the result is that you only need to deal with a single power cable, making the Celsius 24 the cleanest cooler on test in terms of cables.

Both the pump and fans are controllable, and there two modes from which to choose. PWM mode simply taps into the signals from your motherboard, while Auto mode is based on coolant temperature. Either way, the Celsius 24 is exceptionally quiet at low loads, and was 3dBA quieter than the Corsair H100i Pro RGB (see p50) at full speed too.

Installation involves dealing with the usual Asetek mounting mechanism, which is straightforward on LGA2066, LGA115x and Socket AM4, with the latter being supported out of the box despite this cooler's age. You either use the standard AMD backplate, or the included one for LGA115x motherboards, where pins secure from the top side to hold it in place, before securing the pump to the pins with thumbscrews. Thermal paste is pre-applied too, so it's a very easy cooler to install.

The fans are able to spin at up to 2,000rpm, so they offer plenty of power at full speed. Meanwhile, the radiator has detachable G1/4in fittings, so it's possible to expand the loop with a reservoir or GPU waterblock, especially as the CPU waterblock and radiator are made from copper, so there's no risk of galvanic corrosion if you add extra copper components.

The Celsius 24 put in a decent effort in all of our test systems, coming within 1°C of the top spot when dealing with our Core i5-8600K, although it only managed a mid-table result in our toasty LGA2066 system, with a CPU delta T of 58°C compared to 54°C for the NZXT Kraken X52 (see p55) and 51°C for the EK Water Blocks Phoenix EK-MLC 240 (see p52). Its CPU delta T of 46°C was reasonable in our AM4 system too, but again it was outstripped by the Corsair, NZXT and EK Water Blocks coolers.

Conclusion

The Fractal Design Celsius 24 is still a solid cooler for any CPU socket, but the competition has caught up with this once great cooler and, despite its low noise, easy installation and clean cabling, you can now get better cooling, modern features and RGB lighting for the same or less cash.

Corsair's H100i Pro RGB costs the same price and has all of the above, while the Alphacool Eisbaer LT 240 is expandable and costs £20 less than the Fractal, making the Design Celsius 24's £100 price tag a little too steep.

VERDICT

Still a good cooler, but the latest competition now offers similar capabilities and more features for a similar price.

/SPECIFICATIONS

Compatibility Intel: LGA2011/v3, LGA115x, LGA1366; AMD: Socket AM4, AM3/+, AM2/+, FM2/+, FM1

Radiator size with fans (mm) 123 x 284 x 56 (W x D x H)

Fans 2 x 120mm

Stated noise Up to 32.2dBA

LGA1151 RESULTS

COOLING	FEATURES	OVERALL SCORE
37/40	10/20	81%
DESIGN	VALUE	
18/20	16/20	
FITTING		
EASY		

LGA2011 RESULTS

COOLING	FEATURES	OVERALL SCORE
35/40	10/20	79%
DESIGN	VALUE	
18/20	16/20	
FITTING		
EASY		

AM4 RESULTS

COOLING	FEATURES	OVERALL SCORE
34/40	10/20	75%
DESIGN	VALUE	
18/20	13/20	
FITTING		
EASY		

Game Max Iceberg 240mm / **£50** inc VAT

LGA1151/ LGA2011

SUPPLIER www.scan.co.uk

Despite costing less money than many 120mm all-in-one liquid coolers, the Game Max Iceberg 240mm has a fully-fledged 240mm radiator, and it even offers lighting too. However, while the pump is illuminated and colours change on rings that surround the fans, you can't control the lighting – that's fine if you don't mind the full colour spectrum spilling out all the time, but it's not great if you want to use specific effects or colour-match the lighting to the rest of the PC. Thankfully, the display looks quite pleasant, and it will help to brighten up your PC's interior if the rest of the gear is budget-focused.

The fans are rated at 1,800rpm, so they have a reasonable amount of grunt, and there's a PWM splitter cable included, so you only need a single fan header to power them. The pump only has a 3-pin power connector, but many modern motherboards can control parts with these connectors too.

The installation procedure proved to be a pain on Intel systems though. With LGA115x sockets, you have to hold a backplate in place, hold the cooler (having installed mounting brackets to it) and secure the cooler to the backplate with small screws, all at the same time.

This installation process meant we had to remove the motherboard. Plus, even with our LGA2066 motherboard, we had to hold the cooler in place while trying not to let the securing pins fall out of our magnetic screwdriver – you can't really secure them by hand. Meanwhile, the AMD mount uses the existing plastic socket mounts, but didn't feel as secure as those on the Intel and NZXT coolers.

In terms of noise, the Iceberg 240mm registered a very low 51dBA on our meter. However, the pump had a distinct whine that was audible outside the case. It's far from annoying, but every other cooler had a quieter pump.

Performance was reasonable in our LGA1151 system, though, with a CPU delta T of 48°C, which is just 4°C warmer than the best result – a fantastic performance for a cooler that costs just £50 inc VAT.

It was less competitive in our LGA2066 system, where our overclocked Core i9-7900X pushed the delta T to 61°C, which was 7°C warmer than the NZXT Kraken X52 and 2°C warmer than the Alphacool Eisbaer LT 240. Our concerns over the AM4 mount seem justified too, as the AM4 CPU delta T of 55°C was 7°C warmer than the next full-speed result, despite several attempts to remount the cooler.

Conclusion

Despite the slightly troublesome installation, the Game Max Iceberg 240mm performed excellently for the cash in both our Intel systems, dealing with the heat just as well as other coolers. It doesn't top the cooling charts, but it keeps up with coolers costing considerably more money. It's not the quietest cooler either, but if you're on a tight budget and want to overclock your CPU, it's a compelling money saver for Intel systems.

VERDICT

Fiddly installation and a noisy pump compared with the competition, but it offers great cooling for the money.

/SPECIFICATIONS

Compatibility Intel: LGA2011/v3, LGA115x, LGA1366; AMD: Socket AM4, AM3/+, AM2/+, FM2/+, FM1

Radiator size with fans (mm) 120 x 275 x 52 (W x D x H)

Fans 2 x 120mm

Stated noise Up to 32dBA

LGA1151 RESULTS

COOLING	FEATURES	OVERALL SCORE
35/40	14/20	80%
DESIGN	VALUE	
11/20	20/20	
FITTING		
MEDIUM		

LGA2011 RESULTS

COOLING	FEATURES	OVERALL SCORE
31/40	14/20	79%
DESIGN	VALUE	
14/20	20/20	
FITTING		
MEDIUM		

AM4 RESULTS

COOLING	FEATURES	OVERALL SCORE
26/40	14/20	74%
DESIGN	VALUE	
14/20	20/20	
FITTING		
EASY		

NZXT Kraken X52 / £120 inc VAT

SUPPLIER www.overclockers.co.uk

LGA1151/ LGA2066

AM4

Topping the features chart, thanks to RGB lighting, software control and the inclusion of additional fan screws for extra fans, the NZXT Kraken X52 also demands a hefty premium. At £120 inc VAT, only the EK Water Blocks EK-MLC 240 (see p52) is more expensive and Corsair's similar H100i Pro RGB (see p50) costs noticeably less money too. However, the Kraken X52 ticks a lot of boxes.

Its lighting show still looks great, despite the cooler now being two years old. You can choose from anywhere in the full RGB colour pallet, and it sports a funky reflecting light show, with the centre display on the pump looking as though it goes on for infinity. The fans aren't illuminated, but you do get extra screws to mount two more fans if you want to boost cooling further with a push-pull setup.

You do have to deal with a number of cables, though, despite NZXT's CAM software controlling all the gear. The fan splitter cable runs off the pump and also has a SATA power lead. There are two extra fan connectors as well, plus a USB cable to attach to your motherboard so the software can communicate with the Kraken X52. There are many cables, but a dozen cable ties will soon sort it out. The software itself offers a variety of information and control over the pump and fans. Like the Corsair H100i Pro RGB, it's set to respond to coolant temperature rather than the CPU by default, but you can alter this setting in the software.

Meanwhile, installation uses the familiar Asetek mounting components with support for AM4 out of the box, and we had no issues installing the cooler on any of our CPU sockets. The tubing is relatively long too, allowing the radiator to be mounted in the front or roof of a case, and the tube fittings on the pump can rotate easily as well.

With silent mode set in the software, the Kraken X52's performance was hindered by the fact that the fans and pump were responding to the coolant temperature and not the CPU. However, our CPU was still nowhere near overheating and this setting also meant the cooler was supremely quiet, dishing out just 38dBA.

The result, though, was a hefty delta T on all our systems, adding at least 12°C, usually more, to the maximum temperature. Set it to monitor the CPU rather than the coolant, though, and the tables turn, with the Kraken X52 blasting up the graphs, to joint first place in our LGA1151 system, joint second in the LGA2066 system and second again in the AM4 system. The downside is that this setting made the cooler a lot louder at 55dBA, although it was still a little quieter than the Corsair H100i Pro RGB at full speed.

Conclusion

The level of control offered by NZXT's CAM software offers is excellent, although we recommend tweaking switching from the default Silent mode, either to Extreme mode or using the CPU as the temperature input to activate the fans earlier. Otherwise, though, the Kraken X52 is easy to install, feature-rich and offers amazing cooling. It also has the means to add additional fans and looks great. It's not cheap, but it's a great cooler if you can afford the extra £20 over the Corsair.

VERDICT

A great-looking liquid cooler with excellent performance in high-speed modes, as well as a useful software suite.

/SPECIFICATIONS

Compatibility Intel: LGA2011/v3, LGA115x, LGA1366; AMD: Socket AM4, TR4, AM3/+, AM2/+, FM2/+, FM1

Radiator size with fans (mm) 123 x 275 x 55 (W x D x H)

Fans 2 x 120mm

Stated noise Up to 36dBA

LGA1151 RESULTS

COOLING	FEATURES	OVERALL SCORE
38/40	19/20	92%
DESIGN	**VALUE**	
19/20	16/20	
FITTING		
EASY		

LGA2011 RESULTS

COOLING	FEATURES	OVERALL SCORE
36/40	19/20	90%
DESIGN	**VALUE**	
19/20	16/20	
FITTING		
EASY		

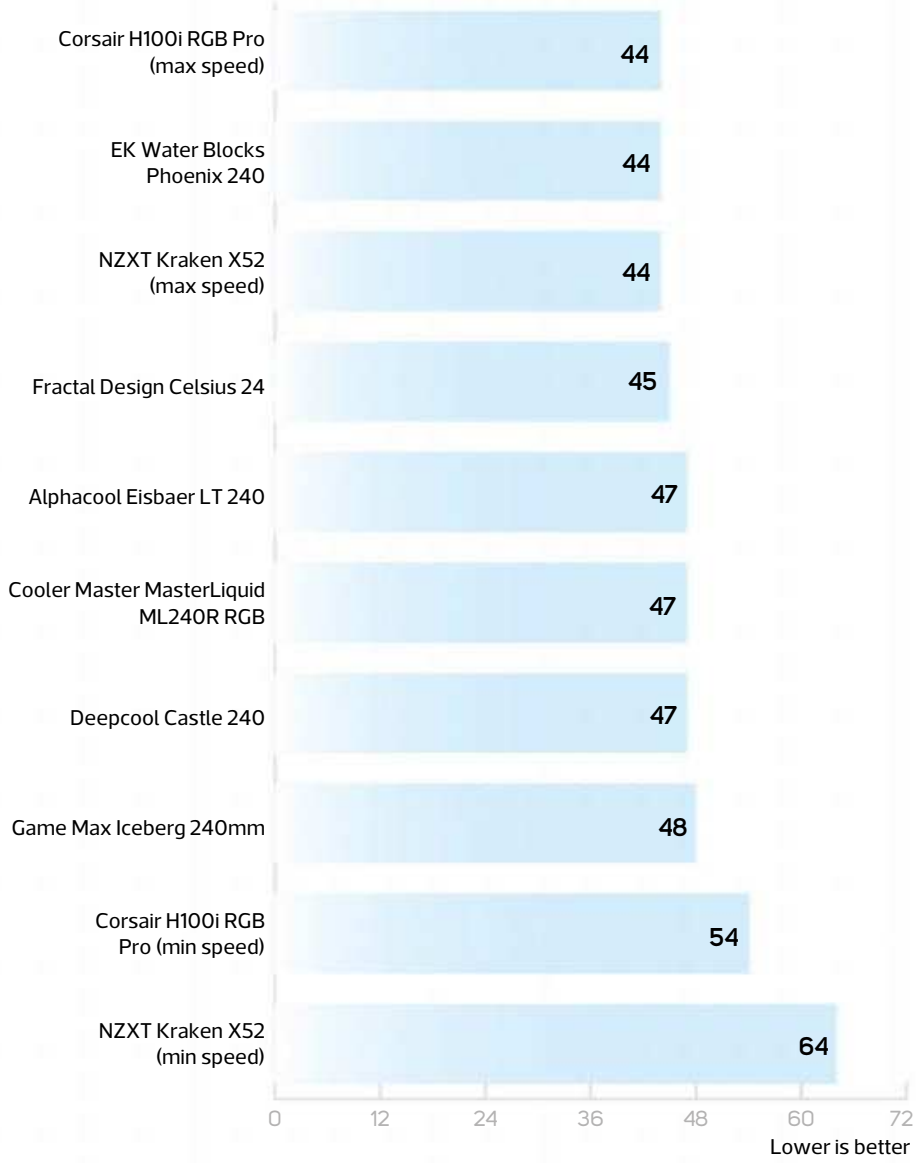
AM4 RESULTS

COOLING	FEATURES	OVERALL SCORE
37/40	19/20	87%
DESIGN	**VALUE**	
19/20	12/20	
FITTING		
EASY		

CPU COOLER RESULTS

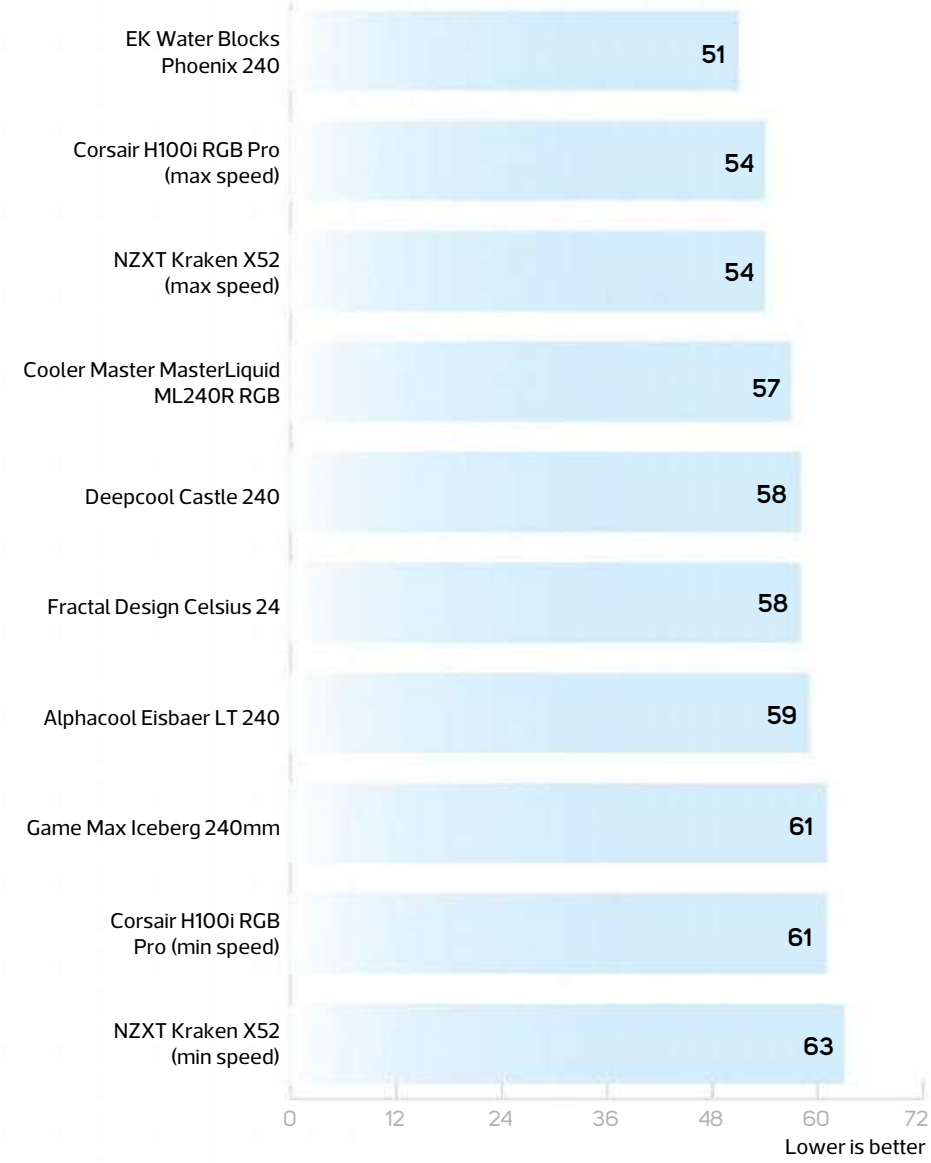
INTEL LGA1151

Delta T (°C)



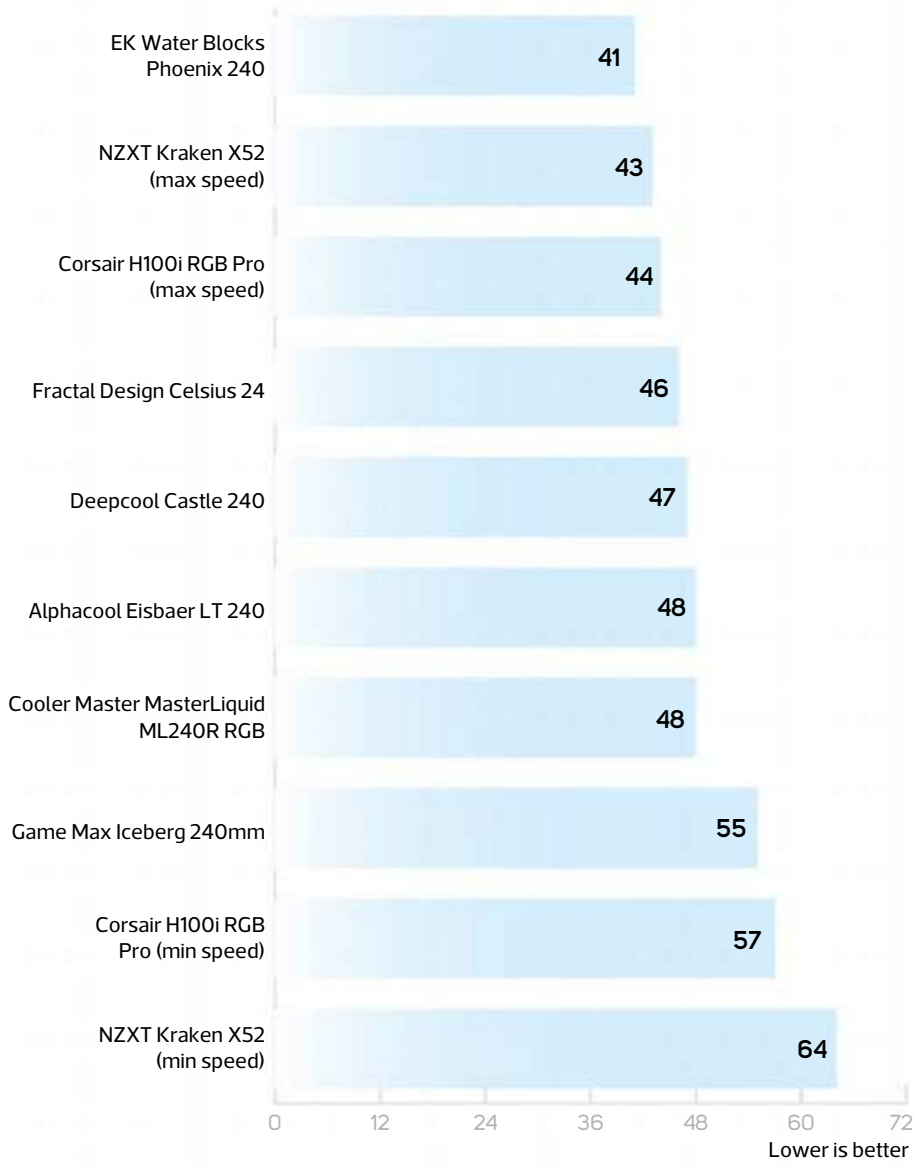
INTEL LGA2066

Delta T (°C)

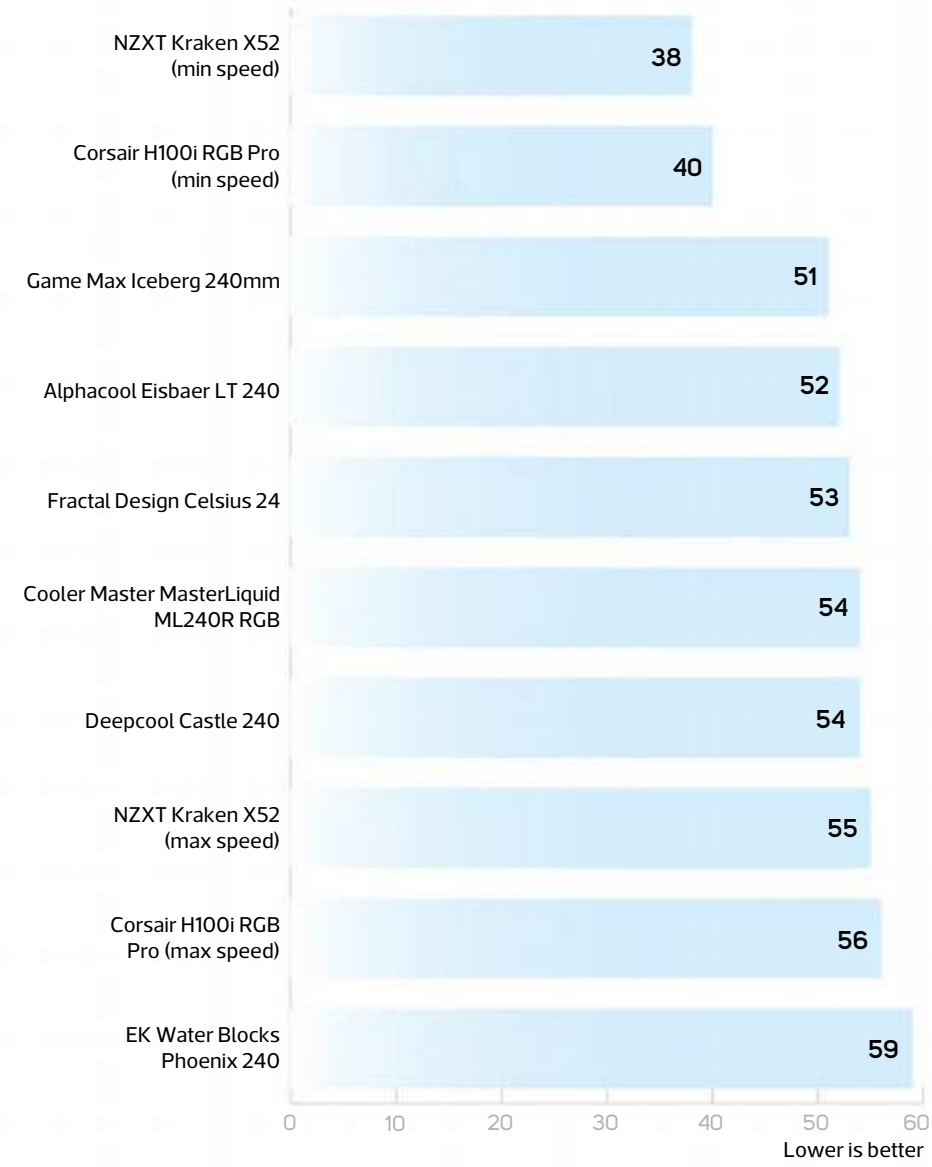


AMD AM4

Delta T (°C)



NOISE LEVEL (dBA)



EARLY BIRD OFFER! 1ST – 31ST OCTOBER

AN EXTRA

10% OFF

CHRISTMAS

PRICES

Power up for Christmas with additional savings
on all of your favourite technology magazines!

VISIT **magazinedeals.co.uk/tech**

OR CALL **0330 333 9493** quoting code: **EBSALE**

PC system reviews

GAMING PC

Scan 3XS Vengeance RTX Ti / £3,000 incVAT

SUPPLIER www.scan.com

Scan's 3XS Vengeance RTX Ti is the first system we've seen with Nvidia's new flagship GeForce RTX 2080 Ti GPU. It's the top-end Turing chip, and Scan has chosen a huge, triple-slot card to demonstrate the new technology. The EVGA-made XC Ultra has a whopping 105MHz factory overclock, and Scan has added an extra 150MHz, giving you standard and boost speeds of 1605MHz and 1800MHz.

Based on Nvidia's TU102 GPU, the RTX 2080 Ti gives you 4,352 stream processors, and 11GB of GDDR6 memory, as well as the numerous improvements of the Turing architecture, including real-time ray-tracing support and DLSS, neither of which are enabled in any games yet.

The XC Ultra is massive, with its black PCB topped with a huge heatsink and two large fans, and there are numerous RGB LEDs.

The flagship GPU is joined by a Core i7-8086K processor. It's a 6-core Coffee Lake CPU with Hyper-Threading, and Scan has overclocked its 4GHz stock speed to 5GHz across all cores – a huge boost.

An Asus ROG Strix Z370-F Gaming motherboard houses the components. It's the same motherboard Chillblast used in the more affordable Fusion Juggernaut 2080 (see p62), and it has the key features we expect from a gaming board. There are steel-supported PCI-E slots with full dual-GPU support, spare memory and SATA ports, and two M.2 connectors, one of which is free. It has the usual RGB LEDs and chunky heatsinks, and the rear I/O panel is covered with a metal shroud.

We have no concerns about memory speed or support, and the S1220A-based SupremeFX audio is solid too. The rear I/O panel only has three full-sized USB 3.1 ports, alongside a single USB Type-C connector, but that's only a minor concern.

Scan has installed a whopping 32GB of 3000MHz DDR4 memory too, while the 500GB Samsung 970 Evo and 2TB hard disk are a decent combo, offering fast storage with plenty of room for Windows and games, plus some extra data storage space.

It's all powered by a Corsair TX550M PSU, which has an 80 Plus Gold efficiency rating and a semi-modular design, although the relatively modest power rating will rule out adding a second RTX 2080 Ti card later.

All the hardware is installed in a Corsair Carbide 275R TG mid-tower enclosure with sober, understated looks and impressive build quality – the aluminium and tempered glass used throughout the design is rock-solid. There's a magnetic dust filter on the top, rubber grommets around the cable-routing holes and Scan has done its usual excellent job with keeping the cables neat. Meanwhile, a strip of RGB LEDs at the top of the chassis bathes the machine in a soft blue light.

At the rear, there's one 3.5in bay and two 2.5in bays, while the Corsair Hydro H100i Pro liquid-cooling radiator is attached to the front of the chassis with two 120mm fans for air intake, and there's a 120mm exhaust fan.

It's easy to reach the memory slots, but the case's compact dimensions and PSU shroud make accessing the bottom of the board fiddly, especially with the huge graphics card installed. The graphics card also blocks two 1x PCI-E slots although, to be fair, you're unlikely to need much in the way of expansion cards.

The usual Scan warranty is in place too, which means you get three full years of parts and labour coverage – and pleasingly, a year of on site service as well.

/SPECIFICATIONS

CPU 4GHz Intel Core i7-8086K overclocked to 5GHz

Motherboard Asus ROG Strix Z370-F Gaming

Memory 32GB Corsair Vengeance RGB 3000MHz DDR4

Graphics EVGA GeForce RTX 2080 Ti 11GB

Storage 500GB Samsung 970 Evo M.2 SSD, 2TB Seagate Barracuda hard disk

Case Corsair Carbide 275R TG

Cooling CPU: Corsair Hydro H100i Pro with 2 x 120mm fans; GPU: 2 x 90mm fans; top: 1 x 120mm fan; rear: 1 x 120mm fan

PSU Corsair TX550M 550W

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

Operating system Microsoft Windows 10 Home 64-bit

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

Performance

The RTX 2080 Ti handles any current game at 4K with no trouble. It zipped through Shadow of the Tomb Raider without dropping below 53fps, and it was only 1fps slower in Deus Ex: Mankind Divided. The RTX 2080 Ti returned a rapid average of 47fps in Total War: Warhammer II. Its minimum of 15fps is unusually low, but that appears to be due to the RTX beta driver, and will hopefully be fixed soon.

ELITE
NEW ENTRY
P64

1 The monstrous EVGA RTX 1080 Ti card dominates the interior

2 All six of the Core i7-8086K's cores are overclocked to 5GHz

3 Scan has done its usual excellent job with keeping the cables neat

Even without its extra features enabled, the RTX 2080 Ti is much more powerful than the GTX 1080 Ti. Last month's Palicomp i7 Arctic Glacier included an overclocked GTX 1080 Ti, but it could only manage a 36fps minimum in Deus Ex at 4K, for example.

The CPU is quick too, although its image editing and Handbrake scores exhibit similar performance levels to an overclocked Core i7-8700K. Thanks to its 32GB of 3000MHz memory, this system's multi-tasking score of 221,824 is particularly good too.

There's enough CPU power here to play any game in any scenario, and to handle almost any productivity task. You'll only run into difficulty if you're trying to run very heavily multi-threaded workstation software. The SSD is solid too, with read and write speeds of 3,612MB/sec and 2,486MB/sec respectively.

The final performance point, thermals, sees the Scan continue to impress. It's near-silent when idle, and the noise only increased very slightly during gaming and full-system stress tests. Scan has augmented the Corsair Hydro with a custom fan profile to keep the noise down, and it clearly works – you'll only hear this machine if you're sitting in silence alongside the chassis. The temperatures are fine too, with solid CPU and GPU delta Ts of 55°C and 51°C respectively.

Conclusion

Scan's machine appears subtle from the outside, with its small enclosure and lack of fan noise, but the components are the real stars. The overclocked RTX 2080 Ti delivers enough performance to conquer any current game. The overclocked CPU is very fast and the motherboard, memory and storage are stellar. The only issue is that spending the extra cash on a Turing-based PC is a gamble right now, as there are no games using its advanced features. If you want to take that gamble, though, then Scan's machine is compact, quiet and enormously powerful.

MIKE JENNINGS

CPC REALBENCH

64,630	442,312	149,247
GIMP IMAGE EDITING	HANDBRAKE H.264 VIDEO ENCODING	LUXMARK OPEN CL
221,824	**189,653**	**165.7%**
HEAVY MULTI-TASKING	SYSTEM SCORE	INTEL PERFORMANCE INDEX SCORE

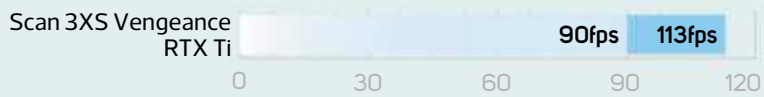
PERFORMANCE	DESIGN	OVERALL SCORE
24/25	23/25	90%
HARDWARE	VALUE	
23/25	20/25	

VERDICT

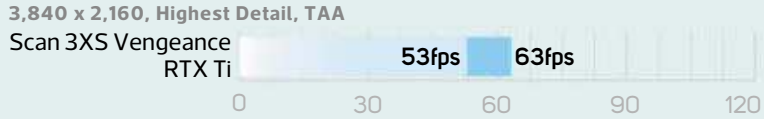
Fast, quiet and well designed, although spending this much money on an RTX 2080 Ti is currently a gamble.

SHADOW OF THE TOMB RAIDER

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



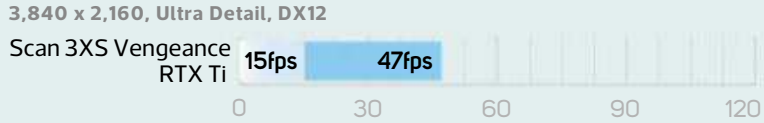
3,840 x 2,160, Highest Detail, TAA



TOTAL WAR: WARHAMMER II

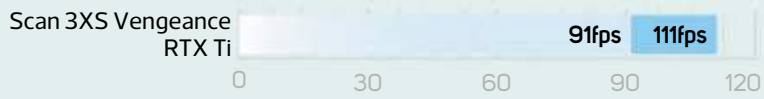
2,560 x 1,440, Ultra Detail, DX12

3,840 x 2,160, Ultra Detail, DX12

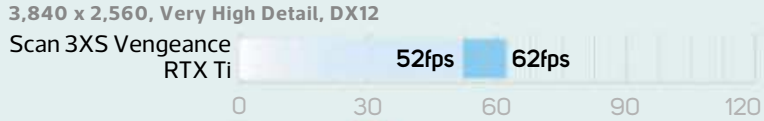


DEUS EX: MANKIND DIVIDED

2,560 x 1,440, Very High Detail, DX12



3,840 x 2,560, Very High Detail, DX12



Minimum Average

GAMING PC

Wired2Fire Diablo RTX / £1,899 inc VAT

SUPPLIER www.wired2fire.co.uk

The Wired2Fire Diablo RTX is one of two machines in this month's issue that deploy the new RTX 2080, and with the same Palit GamingPro OC card too, which raises the 1710MHz boost clock up to 1815MHz. That's a solid leap, which makes this Palit card 15MHz faster than Nvidia's overclocked Founders Edition.

The RTX 2080 GPU itself gets you 2,944 stream processors, 8GB of GDDR6 memory and DisplayPort, HDMI and USB Type-C outputs. Based on Nvidia's new Turing architecture, the RTX 2080 also has 46 RT cores for ray tracing and 368 Tensor cores for Deep-Learning Super Sampling, but those features aren't supported by any games yet.

In Deus Ex its 4K minimum was 11fps quicker than the GTX 1080

Wired2Fire has paired the Palit card with a Core i7-8700K overclocked to 4.7GHz. It's a familiar workhorse, and its six Hyper-Threaded cores ensure that it won't bottleneck games and will handle most other tasks, including streaming and media creation.

Those key components attach to an Asus TUF Z370-Plus Gaming motherboard, which Asus claims is designed for durability, which means you get shielded audio circuits, electrostatic discharge protection, and military-grade chokes and capacitors. However, many of those features are included on other high-end gaming motherboards anyway, and gaming PCs aren't likely to be put under the kind of stress that require military-grade hardware anyway.

Get beyond the branding and the motherboard ticks the basic boxes. It sports USB Type-C, RGB LEDs, steel-supported PCI-E slots and two M.2 connectors. There's no doubt that it has weaknesses though. It doesn't support Nvidia SLI, and the backplate only has three audio jacks. The Asus ROG Strix Z370-F Gaming in the Chillblast Fusion Juggernaut 2080 (see p62) is better, with more audio ports, a better audio codec and better dual-GPU support.

Wired2Fire has also included 16GB of GeIL Super Luce DDR4 memory, which looks gorgeous, although it's a little slow at 2400MHz. You also get a super-fast 512GB Samsung 970 Pro SSD and a 2TB hard disk.

Likewise, the Kolink KL-850M PSU is fine, but it's a step behind the Corsair unit inside the Chillblast. The Kolink is semi-modular, it has an 80 Plus Bronze rating and its 850W peak output is unnecessarily high. The case comes from Kolink too.

The Horizon RGB is smaller and squarer than the Chillblast's Corsair Carbide, and it looks smart, with RGB-illuminated fans in the front panel, a tempered glass side panel and a magnetic dust filter on the top.

A metal shroud hides the PSU, and a Cooler Master MasterLiquid 240 radiator sits in the front of the chassis. The rig is tidy at the front, with cut-outs in the PSU shroud used to hide cables. At the rear, there's a control box for more lighting, and room for one more hard disk, but it's very untidy here – at least you can't see it through the side panel.

The Horizon certainly gets the basics right, but it's cheaper than the Chillblast's Corsair Carbide SPEC-OMEGA and it shows. There are no rubber grommets on the cable-routing holes and the storage mounts are basic. The top panel is flimsy, and the design is derivative of numerous other cases with front-mounted RGB LED fans. Still, it's a respectable case if you're looking to save a bit of cash.

The warranty is decent too, with three years of return to base coverage that includes two years of parts cover. Chillblast, however, offers an additional two years of labour cover, plus two years of collect and return service.

Performance

The RTX 2080 and overclocked Core i7 processor outpaced the Core i5-based Chillblast in games, but only just. In Shadow of the Tomb Raider, the Wired2Fire's 4K minimum of 41fps is 2fps quicker, for example, and its Deus Ex average is 3fps quicker too. As in other tests with Nvidia's beta RTX driver in this issue, the Total War: Warhammer II

/SPECIFICATIONS

CPU 3.7GHz Intel Core i7-8700K overclocked to 4.7GHz

Motherboard Asus Z370-TUF Plus Gaming

Memory 16GB GeIL Super Luce RGB 2400MHz DDR4

Graphics Palit GeForce RTX 2080 8GB

Storage 512GB Samsung 970 Pro M.2 SSD; 2TB Seagate Barracuda hard disk

Case Kolink Horizon RGB

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

PSU Kolink KL-850M 850W

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

Operating system Microsoft Windows 10 Home 64-bit

Warranty Two years parts and labour, followed by one year labour only, return to base

1 The Palit RTX 2080 card is faster than the 1080 Ti in some game tests

2 It's great to see an overclocked Core i7-8700K in this price league

3 The GeIL RAM looks lovely, although it only runs at 2400MHz

minimums were low, but hopefully this issue will be fixed with a future driver update. Either way, it clearly has the power for 4K gaming.

The RTX 2080 compares well with its predecessors too. In Deus Ex its 4K minimum was 11fps quicker than the GTX 1080, and it's even a little faster than the GTX 1080 Ti. That's no surprise given that the RTX 2080's price roughly tallies with the price of the GTX 1080 Ti.

Not surprisingly, the Wired2Fire beat the Chillblast in CPU benchmarks too. Its big gains came in our heavily multi-threaded Handbrake test, where its Hyper-Threading support put it more than 100,000 points ahead. Both machines are quick enough for gaming and everyday computing, but the Wired2Fire is the better option if you want to do work alongside your play. The SSD is no slouch either, with read and write speeds of 3,564MB/sec and 2,318MB/sec respectively.

The downside to the Wired2Fire is more noise. It's on a par with the whisper-quiet Chillblast when idle, and it's not too loud in gaming tests, but the fans ramped up a little and modulated during CPU tests. That's an unlikely real-world scenario, though, and the temperatures were fine, with CPU and GPU delta Ts of 42°C and 56°C.

Conclusion

The new RTX 2080 has enough pace to beat Pascal cards for pure gaming performance, but there's currently still a question mark over ray tracing and DLSS. Away from the GPU, the Wired2Fire takes a different approach to Chillblast. Its motherboard, power supply and case aren't as good, but they're adequate – especially if you don't want to upgrade. Instead, the Diablo offers more CPU power and a lower price, making it faster than its rival in applications. It's not quite as elegant as the Chillblast, but it's still worth considering if you want to save some money and multi-threaded CPU power is a priority.

MIKE JENNINGS

CPC REALBENCH

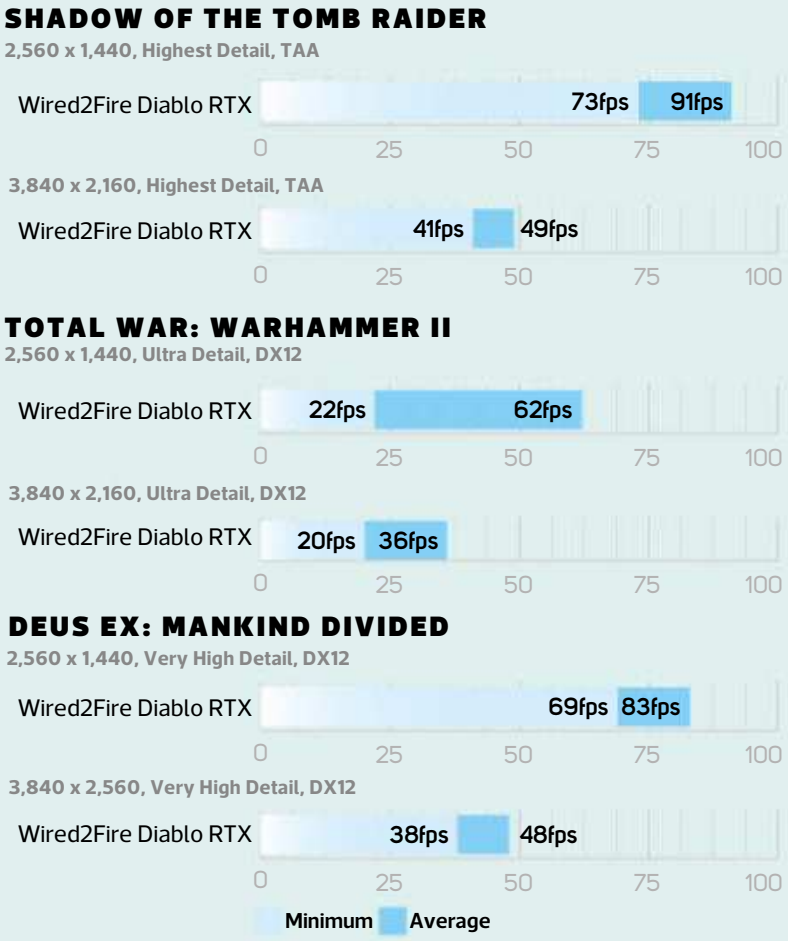
GIMP IMAGE EDITING	HANDBRAKE H.264 VIDEO ENCODING	LUXMARK OPEN CL
64,389	455,073	119,718

HEAVY MULTI-TASKING	SYSTEM SCORE	INTEL PERFORMANCE INDEX SCORE
208,439	187,961	164.23%

PERFORMANCE	DESIGN	OVERALL SCORE
23/25	21/25	87%
HARDWARE	**VALUE**	
21/25	22/25	

VERDICT

A cracking spec for the money, and a decent build, although it lacks the competition's panache.



GAMING PC

Chillblast Fusion Juggernaut 2080 / £2,050 inc VAT

SUPPLIER www.chillblast.com

As the digits on the end of its name suggest, Chillblast's Fusion Juggernaut 2080 has one of Nvidia's latest GPUs slotted into the motherboard. In this case, the card is a Palit Gaming Pro OC model, as with the Wired2Fire Diablo RTX (see p60). This version of the card overclocks the RTX 2080's core from 1515MHz to 1620MHz, which means a revised boost speed of 1710MHz.

The RTX 2080 uses Nvidia's new Turing GPU architecture (see p20). On one hand, that means you get numerous upgrades that enhance conventional GPU performance. On the other, though, it means you get also 46 RT cores and 368 Tensor cores for ray tracing and Deep-Learning Super Sampling respectively – features that haven't been implemented in any real games yet, and which bump up the price significantly. We're waiting for Windows updates, new games and patches to see if these improvements will have a significant impact.

The new GPU sits alongside a Core i5-8600K processor, which has been overclocked from 3.6GHz to 4.8GHz, and it has the same Coffee Lake architecture as the Core i7-8700K inside the Wired2Fire. However, the 6-core i5-8600K doesn't have Hyper-Threading, which gives the Core i7 part an advantage in heavily multi-threaded software. Chillblast has paired the main components with 16GB of 2666MHz DDR4 memory, a 500GB Samsung 970 Evo SSD and a 3TB hard disk. The RAM speed is a step from the Wired2Fire's 2400MHz RAM, and the 3TB hard disk is a little larger.

All the gear is plugged into an Asus ROG Strix Z370-F Gaming motherboard. It's a conventional gaming board, with angular heatsinks, RGB LEDs and a chunky shroud over the rear I/O panel. It has two M.2 slots, full dual-graphics support, spare memory slots, and plenty of vacant headers and connectors.

The Strix board doesn't have on-board buttons and displays, but it's not missing any other major features. It's also more versatile than the Asus TUF board inside the cheaper Wired2Fire, with more audio jacks, wider dual-GPU options and a third 16x PCI-E slot. The Chillblast's power supply is better too. The Corsair RM750x has ample power for a second GPU, as well as a fully modular design and an 80 Plus Gold efficiency rating.

The components are packed inside a Corsair Carbide SPEC-OMEGA chassis, which is taller and longer than the Kolink case used by Wired2Fire, and it's more striking: the front panel is an angled, eye-catching mix of dark metal and glass, and the top has more angles and loads of mesh. The side panel is made from tempered glass too, and the build quality is great, with hardly any give in the metal on the top. The increased dimensions mean there's a little more room in the interior than the Kolink case too, and the motherboard tray has rubber around its cable-routing holes. At the rear, there are three neat 2.5in drive caddies, and Chillblast has done a better job than Wired2Fire with cabling around the back. Both systems are similarly neat at the front, though, with careful cable tidying throughout. There's no PSU shroud on the Chillblast, so the bottom looks a little less neat.

There's a decent warranty too, with as full two years of collect and return parts cover, plus three further years of labour only, return to base service.

/SPECIFICATIONS

CPU 3.6GHz Intel Core i5-8600K overclocked to 4.8GHz

Motherboard Asus ROG Strix Z370-F Gaming

Memory 16GB Chillblast 2666MHz DDR4

Graphics Palit GeForce RTX 2080 8GB

Storage 500GB Samsung 970 Evo M.2 SSD, 3TB Seagate Barracuda hard disk

Case Corsair Carbide SPEC-OMEGA

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

PSU Corsair RM750x 750W

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

Operating system Microsoft Windows 10 Home 64-bit

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

Performance

The Palit RTX 2080 is a capable performer, but the Chillblast's Core i5 processor saw this system narrowly fall behind the Wired2Fire in gaming tests, although the margins are small and both machines can run Deus Ex: Mankind Divided and Shadow of the Tomb Raider at 4K with decent settings.

As with other tests we've performed using Nvidia's RTX beta driver this month, the minimum frame rates in Total War: Warhammer II were all over the place, but the Chillblast's average of 36fps indicates that playable speeds aren't far away if you tweak graphics settings. Its results in all our games at 2,560 x 1,440 were also solid.

Meanwhile, the Core i5 processor is fast, with a single-threaded image editing score that's virtually identical to the overclocked Core i7-based Wired2Fire machine. However, the Chillblast's Handbrake result of 327,451 was more than 100,000 points behind the Wired2Fire system, and the

ELITE
NEW ENTRY
P64

1 **An overclocked Core i5-8600K CPU sits under the Corsair cooler**

2 **There's no PSU shroud, but Chillblast has tidied the cables neatly**

3 **The star of the show is a Palit GeForce RTX 2080 graphics card**

Chillblast's overall result was slower too. The Chillblast's chip isn't slow. It will avoid games bottlenecks, and handle every everyday computing tasks, as well as most work applications. However, if you do want a PC that's set up for productivity as well as gaming, the Wired2Fire rig is definitely quicker. The Chillblast's SSD is no slouch either, with read and write speeds of 3,551MB/sec and 2,501MB/sec respectively.

The Chillblast's mid-range CPU and Corsair Hydro H100x cooler also contribute to low noise levels. The Chillblast was consistently quiet, with similar noise levels when idle and undertaking stress tests. When the components were pushed, it was always quieter than the Wired2Fire. Temperatures weren't too bad either. The CPU's peak delta T of 65°C is a little high, but not dangerous. The GPU's peak of 48°C is fine.

Conclusion

The RTX 2080 is a curious new card. While the Turing architecture delivers a solid boost compared with the GTX 1080, and decent pace in 4K games, the absence of ray tracing and DLSS in any current games leaves a question mark over this GPU, especially when it costs so much money.

Aside from the graphics card situation, the Chillblast machine trades blows with its rival. Its motherboard, PSU, case and warranty are all better than those offered by the Wired2Fire, but that machine has more CPU power and a lower price. If you're more concerned with CPU power, and you want to save a little bit of cash, the Wired2Fire is the better option. However, the Chillblast offers a better balance of components, as well as quieter operation and slightly better build quality, making it our preferred option if you're looking for a new RTX rig.

MIKE JENNINGS

CPC REALBENCH

64,307	327,451	126,280
GIMP IMAGE EDITING	HANDBRAKE H.264 VIDEO ENCODING	LUXMARK OPEN CL
184,146	**150,290**	**131.31%**
HEAVY MULTI-TASKING	SYSTEM SCORE	INTEL PERFORMANCE INDEX SCORE

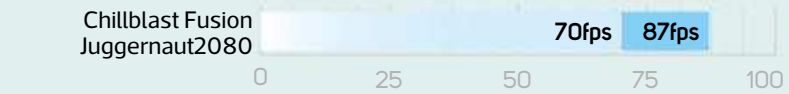
PERFORMANCE	DESIGN	OVERALL SCORE
21/25	23/25	88%
HARDWARE	VALUE	
22/25	22/25	

VERDICT

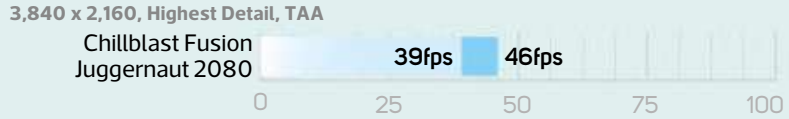
A good balance of speed, hardware and build quality for a fair price, although you only get a Core i5 CPU.

SHADOW OF THE TOMB RAIDER

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



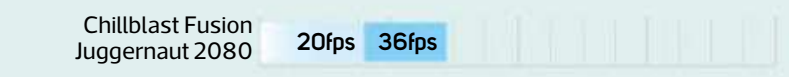
3,840 x 2,160, Highest Detail, TAA



TOTAL WAR: WARHAMMER II

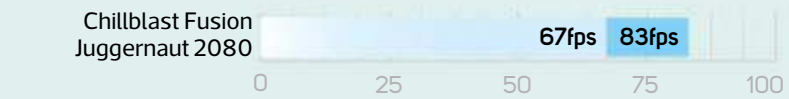
2,560 x 1,440, Ultra Detail, DX12

3,840 x 2,160, Ultra Detail, DX12

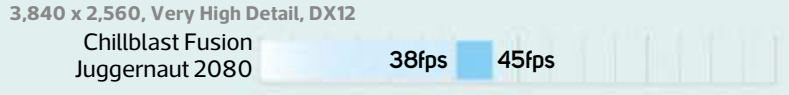


DEUS EX: MANKIND DIVIDED

2,560 x 1,440, Very High Detail, DX12



3,840 x 2,560, Very High Detail, DX12

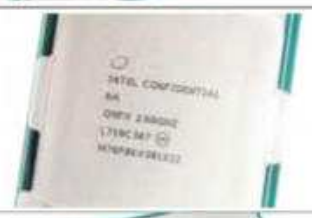


Minimum Average

Elite

Our choice of the best hardware available

Processors

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**ENTRY-LEVEL CPU WITH INTEGRATED GRAPHICS**	AMD Ryzen 3 2200G (AM4)	www.scan.co.uk	Issue 176, p22	£95
	**CPU WITH INTEGRATED GRAPHICS**	AMD Ryzen 5 2400G (AM4)	www.scan.co.uk	Issue 176, p23	£140
	**BUDGET GAMING CPU**	Intel Core i3-8350K (LGA1151-V2)	www.overclockers.co.uk	Issue 175, p46	£219
	**ALL-ROUND 6-CORE CPU**	AMD Ryzen 5 2600 (AM4)	www.scan.co.uk	Issue 179, p21	£150
	**ALL-ROUND 8-CORE CPU**	AMD Ryzen 7 2700X (AM4)	ww.scan.co.uk	Issue 178, p22	£300
	**GAMING 6-CORE CPU**	Intel Core i7-8700K (LGA1151-V2)	ww.scan.co.uk	Issue 175, p56	£450
	**HEAVY MULTI-THREADING CPU**	AMD Threadripper 2950X (TR4)	www.overclockers.co.uk	Issue 182, p23	£810
	**EXTREME MULTI-THREADING CPU**	Intel Core i9-7980XE (LGA2066)	ww.scan.co.uk	Issue 171, p20	£1,890
	**WORKSTATION MULTI-THREADING CPU**	AMD Threadripper 2990WX (TR4)	www.overclockers.co.uk	Issue 182, p24	£1,650

CPU coolers

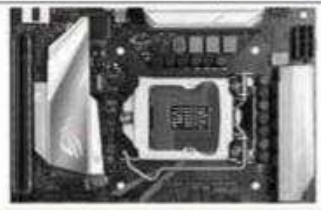
	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**BUDGET AIR COOLER (LGA115X)**	Raijintek Rhea	www.overclockers.co.uk	Issue 163, p86	£16
	**MID-RANGE AIR COOLER (LGA115X, LGA2011, AM4)**	ARCTIC Freezer 33 eSports One	www.amazon.co.uk	Issue 175, p21	£32
	**LOW-PROFILE AIR COOLER (LGA115X, LGA2011)**	Noctua NH-D9L	www.amazon.co.uk	Issue 143, p17	£44
	**120MM ALL-IN-ONE LIQUID COOLER (LGA115X, LGA2011, AM4)**	ARCTIC Liquid Freezer 120	www.awd-it.co.uk	Issue 178, p49	£54
	**120MM EXPANDABLE AIO LIQUID COOLER (LGA115X, AM4)**	Alphacool Eisbaer LT 120	www.watercoolinguk.com	Issue 182, p21	£72
	**240MM ALL-IN-ONE LIQUID COOLER (LGA115X, LGA2011, AM4)**	Corsair H100i Pro RGB	www.ebuyer.com	Issue 183, p50	£100
	**280MM ALL-IN-ONE LIQUID COOLER (LGA115X, LGA2011)**	NZXT Kraken X62	www.overclockers.co.uk	Issue 160, p52	£130
	**360MM ALL-IN-ONE LIQUID COOLER (AM4, LGA115X, LGA2011)**	Corsair H150i Pro	www.scan.co.uk	Issue 175, p29	£145
	**240MM HIGH-END EXPANDABLE WATER COOLER (AM4, LGA2011)**	EK Water Blocks EK-MLC Phoenix bundle	www.overclockers.co.uk	Issue 180, p28	£150
	**THREADRIPPER AIR COOLER**	Noctua NH-U14S TR4-SP3	www.overclockers.co.uk	Issue 173, p30	£75

Virtual reality

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**VR GAMING HEADSET**	Oculus Rift Touch bundle	www.overclockers.co.uk	Issue 177, p82	£399
	**PREMIUM VR GAMING HEADSET**	HTC Vive Pro	www.vive.com/uk	Issue 181, p28	£799

Motherboards

LGA1151-V2

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**ATX BUDGET Z370**	MSI Z370 SLI Plus	www.scan.co.uk	Issue 175, p24	£140
	**ATX MID-RANGE Z370**	Gigabyte Z370 Aorus Ultra Gaming	www.scan.co.uk	Issue 172, p46	£165
	**ATX HIGH-END Z370**	Asus ROG Maximus X Hero	www.scan.co.uk	Issue 172, p43	£254
	**MINI-ITX BUDGET Z370**	Gigabyte Z370N WiFi	www.cclonline.com	Issue 174, p44	£150
	**MINI-ITX MID-RANGE Z370**	Asus ROG Strix Z370-I Gaming	www.scan.co.uk	Issue 174, p43	£193

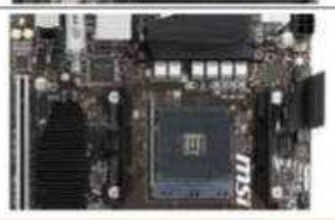
LGA2066

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**ATX PREMIUM X299**	Asus Prime X299 Deluxe	www.cclonline.com	Issue 168, p52	£392
	**ATX MID-RANGE X299**	Asus ROG Strix X299-E Gaming	www.cclonline.com	Issue 168, p50	£318
	**ATX BUDGET X299**	ASRock X299 Killer SLI	ww.lambda-tek.com	Issue 171, p22	£175
	**MICRO-ATX X299**	MSI X299M Gaming Pro Carbon AC	www.cclonline.com	Issue 174, p24	£255
	**MINI-ITX X299**	ASRock X299E-ITX/ac	www.overclockers.co.uk	Issue 174, p26	£380

TR4

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**ATX MID-RANGE X399**	MSI X399 Gaming Pro Carbon AC	www.scan.co.uk	Issue 170, p50	£320
	**ATX PREMIUM X399**	MSI MEG X399 Creation	www.scan.co.uk	Issue 182, p30	£470
	**MICRO-ATX X399**	ASRock X399M Taichi	www.scan.co.uk	Issue 179, p28	£348

AM4

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**ATX HIGH-END X470**	Gigabyte X470 Aorus Gaming 7 WiFi	www.scan.co.uk	Issue 179, p47	£233
	**ATX MID-RANGE X470**	MSI X470 Gaming Pro Carbon	www.cclonline.com	Issue 179, p50	£164
	**ATX BUDGET X470**	Gigabyte X470 Aorus Ultra Gaming	www.box.co.uk	Issue 179, p48	£135
	**MINI-ITX X470**	Asus ROG Strix X470-i Gaming	www.scan.co.uk	Issue 181, p22	£178
	**ATX BUDGET B450**	MSI B450 Tomahawk	www.overclockers.co.uk	Issue 182, p48	£100
	**MICRO-ATX BUDGET B450**	MSI B450M Mortar	www.scan.co.uk	Issue 182, p50	£90
	**MINI-ITX B350**	MSI B350I Pro AC	www.alza.co.uk	Issue 177, p22	£123

Memory

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**8GB DUAL-CHANNEL DDR4**	8GB Corsair Vengeance LPX 3000MHz DDR4 (CMK8GX4M2A2666C16)	www.scan.co.uk	Issue 163, p86	£79
	**16GB DUAL-CHANNEL DDR4**	16GB Corsair Vengeance LPX 3000MHz DDR4 (CMK16GX4M2B3000C15)	www.scan.co.uk	Issue 166, p90	£145
	**16GB DUAL-CHANNEL DDR4 RGB**	16GB Corsair Vengeance RGB Pro 3200MHz DDR4 (CMW16GX4M2C3200C16)	www.scan.co.uk	Issue 180, p30	£170
	**32GB QUAD-CHANNEL DDR4 RGB**	32GB Corsair Vengeance RGB Pro 3200MHz DDR4 (CMW32GX4M4C3200C16)	www.scan.co.uk	Issue 180, p30	£364
	**16GB DUAL-CHANNEL RGB (AMD RYZEN)**	16GB (2 x 8GB) 3466MHz Corsair Vengeance RGB (CMR16GX4M2C3466C16)	www.scan.co.uk	Issue 178, p24	£217

Software

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**OPERATING SYSTEM**	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£105

Graphics cards

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**1,920 X 1,080 GAMING**	Zotac GeForce GTX 1050 Ti 4GB Mini	www.ebuyer.com	Issue 163, p86	£150
	**2,560 X 1,440 GAMING**	Nvidia GeForce GTX 1060 6GB	www.scan.co.uk	Issue 159, p23	£240
	**SMOOTH 2,560 X 1,440 GAMING**	Asus ROG Strix GeForce GTX 1070 Ti	www.ebuyer.com	Issue 173, p20	£472
	**4K GAMING**	Nvidia GeForce GTX 1080 Ti	www.scan.co.uk	Issue 168, p28	£662
 NEW ENTRY	**SMOOTH 4K GAMING**	Zotac GeForce RTX 2080 Ti AMP!	www.scan.co.uk	Issue 183, p20	£1,224

Cases

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**BUDGET ATX**	Phanteks Eclipse P300 Glass	www.overclockers.co.uk	Issue 176, p28	£55
	**SUB-£75 ATX**	NZXT H500	www.box.co.uk	Issue 181, p26	£70
	**SUB-£100 ATX PERFORMANCE**	Phanteks Enthoo Pro M Glass	www.overclockers.co.uk	Issue 161, p24	£95
	**SUB-£150 ATX QUIET**	Fractal Design Define R6	www.cclonline.com	Issue 174, p20	£110
	**SUB-£150 MID-SIZED ATX**	Cooler Master MasterCase H500P	www.cclonline.com	Issue 181, p41	£123
	**HIGH-END ATX CASE**	Phanteks Enthoo Evolv ATX Glass	www.overclockers.co.uk	Issue 169, p43	£135
 NEW ENTRY	**LUXURY ATX CASE**	Cooler Master Cosmos C700M	www.scan.co.uk	Issue 183, p28	£430
	**MINI-ITX TOWER**	Fractal Design Define Nano S	www.scan.co.uk	Issue 153, p22	£62
	**MICRO-ATX**	Fractal Design Define Mini C	www.scan.co.uk	Issue 161, p26	£82
	**BUDGET MICRO-ATX CASE**	Fractal Design Focus G Mini	www.overclockers.co.uk	Issue 180, p46	£50
	**PREMIUM MICRO-ATX**	NZXT H400i	www.overclockers.co.uk	Issue 175, p32	£120

Case fans

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**120MM QUIET FAN (BEST RUN AT 5V)**	Corsair SP120 Quiet Edition	www.scan.co.uk	Issue 155, p56	£15
	**120MM PERFORMANCE FAN (BEST RUN AT 12V)**	Thermaltake Pure S 12 LED	www.amazon.co.uk	Issue 155, p58	£9

Laptops

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**HIGH-PERFORMANCE GAMING LAPTOP**	Scan 3XS LG17 Carbon Extreme	www.scan.co.uk	Issue 159, p30	c.£2,550
	**THIN AND LIGHT GAMING LAPTOP**	Alienware 13	www.alienware.co.uk	Issue 168, p32	c.£1,849
	**BUDGET GAMING LAPTOP**	MSI GE72 7RE Apache Pro	www.saveonlaptops.co.uk	Issue 167, p28	c.£1,137
	**ULTRABOOK LAPTOP**	Razer Blade Stealth	www.razerzone.com	Issue 167, p36	c.£1,350
	**COFFEE LAKE LAPTOP**	Scan 3XS LG15 Vengeance Pro	www.scan.co.uk	Issue 179, p32	c.£1,400

Storage

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**MAINSTREAM HARD DISK**	Western Digital Blue 4TB	www.overclockers.co.uk	Issue 166, p54	£100
	**PERFORMANCE HARD DISK**	Seagate BarraCuda Pro 6TB	www.overclockers.co.uk	Issue 166, p50	£210
	**SATA SSD**	Crucial MX500 500GB	www.ebuyer.com	Issue 176, p43	£80
	**HIGH-PERFORMANCE M.2 SSD**	Samsung 970 Evo 500GB	www.cclonline.com	Issue 179, p24	£144
	**M.2 HEATSINK**	EK Water Blocks EK-M.2 NVMe Heatsink	www.overclockers.co.uk	Issue 178, p87	£11
	**SINGLE-BAY NAS BOX**	Synology DS118	www.box.co.uk	Issue 174, p34	£159
	**DUAL-BAY MEDIA NAS BOX**	Synology DS218play	www.box.co.uk	Issue 174, p34	£211

Monitors

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**BUDGET 24IN FREESYNC MONITOR**	AOC G2460VQ6	www.ebuyer.com	Issue 174, p52	£136
	**24IN 144Hz FREESYNC ESPORTS MONITOR**	Samsung C24FG70	www.amazon.co.uk	Issue 176, p34	£200
	**24IN FREESYNC MONITOR**	ViewSonic XG2401	www.amazon.co.uk	Issue 167, p52	£240
	**24IN G-SYNC MONITOR**	AOC AGON AG241QG	www.box.co.uk	Issue 169, p55	£390
	**27IN 2,560 X 1,440 FREESYNC MONITOR**	Samsung C27HG70	www.ebuyer.com	Issue 171, p28	£497
	**27IN 2,560 X 1,440 G-SYNC MONITOR**	Asus ROG Swift PG279Q	www.scan.co.uk	Issue 155, p48	£686
	**35IN ULTRA-WIDE CURVED G-SYNC MONITOR**	AOC AGON AG352UCG6	www.scan.co.uk	Issue 180 , p52	£770
	**5K MONITOR**	Iiyama ProLite XB2779QQS	www.scan.co.uk	Issue 179 , p34	£696
	**PREMIUM 27IN 4K G-SYNC MONITOR**	Asus ROG Swift PG27UQ	www.scan.co.uk	Issue 181 , p31	£2,300

Networking

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**ROUTER**	Linksys EA9500 Max-Stream	www.amazon.co.uk	Issue 182, p58	£230
	**BUDGET MESH NETWORK**	BT Whole Home Wi-Fi (no router)	www.currys.co.uk	Issue 172, p54	£170
	**PREMIUM MESH ROUTER**	Netgear Orbi (RBK50)	www.amazon.co.uk	Issue 172, p57	£285
	**WI-FI ADAPTOR**	Asus PCE-AC68	www.scan.co.uk	Issue 128, p88	£58
	**PREMIUM ROUTER**	Asus ROG Rapture GT-AC5300	www.overclockers.co.uk	Issue 170, p35	£350

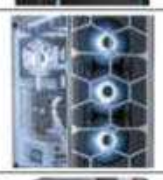
Peripherals

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**MEMBRANE GAMING KEYBOARD**	Corsair Gaming K55 RGB	www.overclockers.co.uk	Issue 176, p52	£50
	**MECHANICAL GAMING KEYBOARD**	Corsair Gaming K68	www.scan.co.uk	Issue 181, p53	£85
	**PREMIUM MECHANICAL GAMING KEYBOARD**	Corsair Gaming K70 RGB Rapidfire	www.ebuyer.com	Issue 154, p21	£120
	**MMO KEYBOARD**	Corsair Gaming K95 RGB Platinum	www.ebuyer.com	Issue 164, p26	£174
	**GAMING MOUSE**	Corsair Glaive RGB	www.box.co.uk	Issue 167, p19	£55
	**AMBIDEXTROUS GAMING MOUSE**	Razer Lancehead Tournament Edition	www.ebuyer.com	Issue 177, p53	£73
	**MMO GAMING MOUSE**	Corsair Scimitar Pro RGB	www.box.co.uk	Issue 164, p24	£69
	**WIRELESS GAMING MOUSE**	Logitech G403 Prodigy Wireless	www.game.co.uk	Issue 171, p40	£100
	STEERING WHEEL AND PEDALS	Logitech G920 Driving Force	www.currys.co.uk	Issue 159, p55	£200

Audio

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**PCI-E SOUND CARD**	Asus Strix Raid DLX	www.scan.co.uk	Issue 148, p28	£175
	**2.1 SPEKAERS**	Acoustic Energy Aego^3	www.amazon.co.uk	Issue 164, p49	£200
	**HEADSET**	HyperX Cloud Alpha	www.currys.co.uk	Issue 173, p50	£90
	**SURROUND-SOUND HEADSET**	Asus ROG Centurion	www.cclonline.com	Issue 163, p49	£185
	**WIRELESS HEADSET**	SteelSeries Arctis 7	www.amazon.co.uk	Issue 178, p58	£128
	**PREMIUM WIRELESS HEADSET**	SteelSeries Arctis Pro + GameDAC	www.scan.co.uk	Issue 179, p31	£250

Systems

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**AMD APU PC**	Falcon Raptor RX	www.falconcomputers.co.uk	Issue 176, p56	c.£550
	**SKYLAKE-X PC**	Scan 3XS Carbon Aura	www.scan.co.uk	Issue 168, p66	c.£2,750
	**BUDGET COFFEE LAKE PC**	PC Specialist Ultima X01	www.pcspecialist.co.uk	Issue 172, p60	c.£1,479
	**MID-RANGE COFFEE LAKE PC**	Palicomp i7 Arctic Glacier	www.palicomp.co.uk	Issue 182, p62	c.£2,500
	**WATER-COOLED COFFEE LAKE PC**	CCL Iris Fusion LQ	www.cclonline.com	Issue 175, p62	c.£3,100
	**PREMIUM COFFEE LAKE PC**	Scan 3XS Vengeance Aura SLI	www.scan.co.uk	Issue 172, p64	c.£3,799
	**DREAM PC**	Scan 3XS Barracuda	www.scan.co.uk	Issue 145, p58	c.£9,499
	**AMD RYZEN 7 PC**	Scan 3XS Horizon Ti	www.scan.com	Issue 179, p64	c.£2,150
	**THREADRIPPER PC**	CyberPower Ultra Threadripper Xtreme	www.cyberpowersystem.co.uk	Issue 171, p62	c.£3,469
	**EXTREME THREADRIPPER PC**	Chillblast Fusion Centauri Ryzen Threadripper Ultimate	www.chillblast.co.uk	Issue 173, p58	c.£7,500
	**MINI-ITX GAMING PC**	Corsair One Elite	www.corsair.co.uk	Issue 177, p60	c.£2,799
	**PREMIUM PC**	Scan 3XS Carbon Fluid Extreme SLI	www.scan.co.uk	Issue 170, p58	c.£4,950
 NEW ENTRY	**GEFORCE RTX 2080 PC**	Chillblast Fusion Juggernaut 2080	www.chillblast.com	Issue 183, p62	£2,050
 NEW ENTRY	**PREMIUM GEFORCE RTX 1080 TI PC**	Scan 3XS Vengeance RTX Ti	www.scan.com	Issue 183, p58	£3,000

Games

Contents

Inverse look p75 / Two Point Hospital p76 / Phantom Doctrine p78 /
We Happy Few p78 / Graveyard Keeper p80 / The engine room – Frozen Synapse 2 p81

OPINION

RICK LANE / INVERSE LOOK

OLD PUNKS

Cyberpunk 2077's demo showed a technological future, but its themes are rooted firmly in the past, argues Rick Lane

One of the most hotly discussed games coming out of E3 this year was CD Projekt's Cyberpunk 2077. While the creator of The Witcher 3 showed a two-minute CG trailer of the new game to the public, it also gave the press the opportunity to watch a 48-minute gameplay demonstration behind closed doors. Most of the journalists who saw it came out breathlessly excited, with many proclaiming it the future of gaming.

As a huge fan of CD Projekt's work, I was naturally thrilled to hear the feedback from Los Angeles. Yet when the developer showed off that same footage online last month, I found myself more concerned than excited. As a raw technical achievement, it looks incredible, combining the scope and visual fidelity of a GTA game, with the microscopic levels of choice offered to a Deus Ex player. We already know from The Witcher 3 that CD Projekt can pull off a game that's both wide and deep.

What I found concerning was CD Projekt's interpretation of the Cyberpunk concept, and how it appears to be exploring this theme. Part of what made The Witcher 3 so enjoyable was its subversion of fantasy tropes, and how it explored themes of fatherhood and love within its war-torn, monster-strewn world.

Cyberpunk 2077, on the other hand, seems to be fully embracing the conventions of its genre. The citizens of Night City sport punk haircuts, wear studded leather jackets and swear like a sailor who has dropped an anchor on his foot. The game's towering cityscape is dominated by all-powerful mega corporations, while everyday citizens scrape a living under the shadow of crisscrossing highway stacks. Everybody you encounter in the world is either sneeringly cynical or outright aggressive, while CD Projekt's idea of a 'mature' experience seems to mean a bucketload of in-your-face violence and nudity.

> The citizens swear like a sailor who has dropped an anchor on his foot

William Gibson, author of the original cyberpunk classic Neuromancer, had similar thoughts. 'The trailer for Cyberpunk 2077 strikes me as GTA skinned-over with a generic 80s retro-future,' he wrote on Twitter. I rather disagree with Gibson's first point, but the latter part is spot on. Cyberpunk is supposed to be at the tipping point of futurism. It's sci-fi on the frontline, with its boots on the ground and a knife between its teeth.

The problem with Cyberpunk 2077 is that, aside from the flying cars, the future it posits has already arrived. Our society *is* dominated by a handful of tech giants: Apple, Facebook and Google. The Internet is omnipresent, constantly watching us and manipulating us as we willingly feed it data. We can track the internal workings of our bodies with fitness watches, and replace missing limbs with the first wave of bionic prosthetics.

Cyberpunk should explore how today's society might look tomorrow. Gibson himself recently went back to the drawing board with his 2014 novel, The Peripheral, which dazzles with not one but two distant yet worryingly plausible futures. Cyberpunk 2077, meanwhile, seems to be offering yesterday's future today, pointing at concepts with which we're already familiar and swearing about it being bad.

I still think Cyberpunk 2077 will be an enjoyable game to play. Its combat looks tremendous, the game world seems impressively open and there's a deep hacking mechanic that lets you assume control of systems within buildings and even people. But for the first time since playing The Witcher in 2007, I'm concerned that CD Projekt RED might have nothing interesting to *say*. CPC

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

Two Point Hospital / £24.99 inc VAT

DEVELOPER Two Point Studios / **PUBLISHER** SEGA / **WEBSITE** www.twopointhospital.com

OVERALL SCORE
90%

/ VERDICT
Funny, engrossing and supremely well made, Two Point Hospital is the perfect cure for anyone suffering management sim blues.

The third most amazing point about Two Point Hospital is that it has taken 20 years for someone to make a genuine successor to Theme Hospital. Bullfrog's last original management sim sold over four million copies and remained in the video game charts for ten years. Despite these figures, though, there hasn't been another hospital management game in the past two decades, and it's taken the original creators of Theme Hospital – Mark Webley and Gary Carr – to found an entirely new studio to make it.

The second most amazing point about Two Point Hospital is that its creators have repeatedly claimed it's not just a spiritual sequel to Theme Hospital. That's complete nonsense.

Two Point Hospital is a sequel to Theme Hospital in all but name, from the distinctly British humour to the room-orientated construction system to the staff constantly moaning at you for a raise. All that's missing from Two Point Hospital is the Bullfrog logo on its cover art.

However, the most amazing point about Two Point Hospital is that the previous most amazing points don't matter, because Two Point Hospital is comfortably the best management sim in years, providing a perfect combination of style, depth and imagination.

Two Point Hospital challenges players with building and maintaining a series of medical facilities across its fictional Two Point County. Your ultimate goal is to achieve a rating of three stars across each of the main game's 15 hospitals, which each offer specific challenges. A hospital at the bottom of a ski slope forces you to contend with a large influx of limb fractures, while a hospital near an abandoned power plant suffers from frequent lightning storms (that's not how power plants work, but since this game isn't Two Point Power Station, who cares?).

Each hospital starts the same way. You need a reception desk, a GP's office for basic diagnostics and a pharmacy for basic treatment, staffed by an assistant, a doctor and a nurse respectively. It's also wise to build a toilet, as you don't want patients being sick in the corridors, and have to hire a janitor to clean up after them.

From this simple core, Two Point Hospital grows. One tough challenge for management sims is providing enough depth to keep players interested without overcomplicating or upsetting the simulation. Two Point Hospital does it beautifully though. It isn't long before

you're building cardiology departments and wards to treat and monitor patients with longer-term sicknesses, as well as specialist treatment rooms such as psychiatry departments, surgeries, and ... clown rehabilitation clinics?

That's the other element that makes Two Point Hospital such fun. Like Theme Hospital, most of the in-game diseases are fictional with a humorous bent. An early condition is light-headedness, where the patient's head turns into a literal light bulb. Other illnesses include Night Fever, where sufferers dress up like John Travolta, and Animal Magnetism (a disease cut from the original Theme Hospital) sees small furry creatures stick to the body of the afflicted.

While some diseases can be cured by a trip to the pharmacy or an hour with a shrink, most of them require specific treatment in bespoke rooms. Light-headedness is cured using a machine that unscrews the glowing light bulb and 3D-prints a replacement head for the patient. Watching these treatments, and indeed the hospital in general, is made an absolute joy thanks to the astonishing work done by Two Point Studios' animators. Even the most basic tasks, such as a janitor cleaning the toilet, are infused with the game's daft sense of humour, as the janitor brandishes his plunger before diving head first into the bowl.

The quality of design goes beyond visuals too. The game excels at mediating both challenge and reward. Although your goal for each hospital is three stars, you only need to unlock one star to move on to the next hospital. You can then return to a previous level once you've unlocked more rooms and equipment to attempt a higher star rating.

Meanwhile, as you complete objectives, you accrue points that can be spent on new items, such as vending machines and magazine stands to keep waiting patients occupied. Surprisingly, few of these items are purely decorative, and even contribute to a hospital's attractiveness rating, making it a more pleasant place for patients.

The underlying simulation impresses too. It has a reasonable amount of depth but, more importantly, it communicates its systems clearly enough so that you can quickly identify and resolve problems with your hospital.

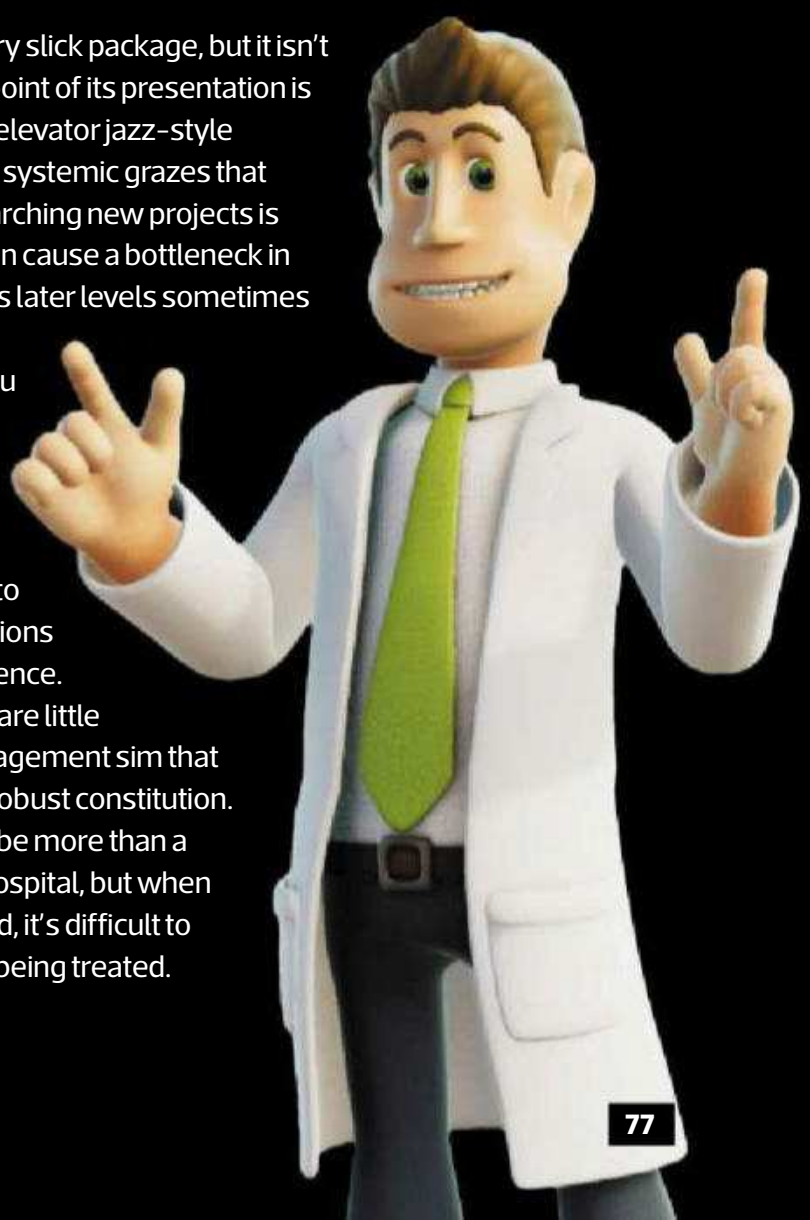
If a queue of more than five patients appears outside your GP's office, for example, the game will flag it up, and suggest building another one to relieve the pressure and

get patients cured faster (which is your primary source of income). Meanwhile, if a room is too cold, you'll see its occupants clutching their arms and shivering, a problem that can be instantly addressed by sprinkling a few radiators around.

Two Point Hospital is a very slick package, but it isn't quite seamless. One weak point of its presentation is its scratchy and unpleasant elevator jazz-style soundtrack. There are a few systemic grazes that need patching up too. Researching new projects is incredibly slow, and can often cause a bottleneck in developing new hospitals, as later levels sometimes rely on you unlocking a new room via research before you can build it. Training your staff in new skills is also fiddly, as it means pulling them out of their jobs for long periods, with no ability to schedule staff shifts or rotations to compensate for their absence.

Fortunately, these issues are little more than a sniffle in a management sim that otherwise demonstrates a robust constitution. Two Point Hospital may not be more than a spiritual sequel to Theme Hospital, but when a sequel is this well designed, it's difficult to complain about how you're being treated.

RICK LANE



Phantom Doctrine / £30.99 inc VAT

DEVELOPER CreativeForge Games/ **PUBLISHER** Good Shepherd Entertainment/ **WEBSITE** www.goodshepherd.games/games/phantom-doctrine

OVERALL SCORE
73%

/ VERDICT
Despite being challenging and often unintuitive, Phantom Doctrine is saved by its tactical depth and the way it embraces its theme.

Phantom Doctrine basically aims to give you XCOM with spies. It puts you in charge of an independent spy network working to bring down a terrorist organisation known as Beholder. You need to build a base, gather intelligence, recruit agents and deploy them on tactical operations across the globe, from small-scale kill/capture ops to more elaborate, story-centric missions.

On the surface, the structure is similar to XCOM. Your time is split evenly between managing your base and controlling your agents on deployment. Base building is very similar to that of Firaxis' strategy classic, while the missions mimic both XCOM's movement and combat systems, right down to the colour of movement pools and camera angles for gunshots.

Lurking underneath these similarities, however, are some important differences that will likely wrong-foot anyone expecting Phantom Doctrine to play like XCOM. Phantom Doctrine ditches percentage chances on whether bullets hit or miss their target. Instead, bullets will always hit unless the opponent has sufficient 'Awareness' to dodge them.

Moreover, Phantom Doctrine places a much greater emphasis on remaining undetected during missions,

letting you disguise your agents and enact stealth takedowns. If you enter open combat, you'll usually be fighting a losing battle. At this point, it's wise to head for the nearest extraction zone before the enemy overwhelms you with infantry reinforcements and pulverising air attacks.

These changes make Phantom Doctrine initially very challenging, as does the enemy AI, which excels at taking advantage of the no-miss mechanic, with the ability to shoot your agents from angles and distances that would be impossible for humans. Furthermore, despite the importance of stealth, the game doesn't provide sufficient

We Happy Few / £39.99 inc VAT

DEVELOPER Compulsion Games/ **PUBLISHER** Gearbox Software/ **WEBSITE** https://compulsiongames.com/en/10/we-happy-few

OVERALL SCORE
40%

/ VERDICT
A great setting and an interesting story can't save We Happy Few from being a tedious and confused game.

We Happy Few's dystopian vision of 1960s England is intriguing and unusual, bolstered by a brilliantly written story that blends the societal oppression of 1984 with the psychedelic themes of the Doors of Perception. Behind the vibrant veneer, however, is a poorly thought-out game that's deeply unpolished.

In the game's alternate past, the Germans won World War II, and the newly installed government keeps the populace in check through a drug called Joy, which fills the dour British sky with rainbows and butterflies, making a meal of roasted rat look like a sweet-filled pinata.

Anyone who doesn't take their Joy is labelled a traitorous 'downer' and is either chased out of town by grinning bobbies, or taken for re-education by prowling doctors.

The story is told from the perspectives of three different characters, all of whom find their own reasons for rejecting the status quo. Despite being the last element added in We Happy Few's lengthy open-alpha development, this core campaign is undoubtedly the game's strongest part.

The campaign successfully balances dark humour with a wicked satirical bite, while the plot is dramatic and filled with interesting twists. An early revelation about the tanks the




stealth-based skills or gadgets to enable many tactical options. You're mostly restricted to using disguised agents to manually knock out enemies, which is slow and tedious.

If you can tolerate Phantom Doctrine's idiosyncrasies, though, there's plenty of depth to its espionage simulation. In the middle of the game, you unlock the MK Ultra facility, which lets you brainwash captured enemies and return them as sleeper agents. Once you acquire silenced weapons, stealth play becomes much more interesting, letting you perform some particularly satisfying room clearances using the game's powerful 'Breach' mechanic.

Phantom Doctrine also nails its setting. Missions always take place at night, often in the rain and under the glow of neon signage, while the slow jazz soundtrack complements the tone beautifully. One of the game's best aspects is a mini-game in which you connect gathered intelligence on a pin board, scanning documents for keywords and linking them with red strings.

Phantom Doctrine may lack slickness and immediacy, but when it all comes together, it's an engrossing simulation of pulp spy fiction.

RICK LANE

Germans left behind after the war is just one of many surprises in store.

Unfortunately, the game supporting this narrative simply isn't worth the 30-odd hours it demands. Despite aesthetic similarities to BioShock, We Happy Few plays like a survival game, featuring large, procedurally generated villages and towns, and placing a heavy emphasis on crafting as its core mechanic. Sadly, neither of these features complements the game at all. The procedural generation simply results in a map that's too large and repetitive, while the rudimentary crafting system produces too many items, of which only a handful are actually useful.

One of the game's more interesting systems requires you to blend into your surroundings to avoid detection, which often means taking Joy, but in practice, it's more annoying than fun.

Joy wears off too quickly, and the withdrawal symptoms alert anyone nearby to your downer state, often resulting in the entire town chasing after you. Eventually, We Happy Few lets you craft a different drug that works like Joy with none of the drawbacks. It says a lot about the game that half its upgrade tree is dedicated to removing such player hindrances rather than adding new features.

The central story missions suggest what We Happy Few should have offered us, involving sneaking into heavily guarded restricted areas, many of which boast impressive brutalist architecture. Sadly, both the stealth and melee combat are very basic, with neither offering the tension of Thief nor the flexibility of Dishonored. In the end, We Happy Few is more British than it intends, concealing its flaws and insecurities beneath a falsely pleasant demeanour.

RICK LANE


Graveyard Keeper / £15.49 inc VAT

DEVELOPER Lazy Bear Games / **PUBLISHER** Tinybuild /
WEBSITE www.graveyardkeeper.com

Graveyard Keeper makes a wonderful pitch. Less Stardew Valley and more Death Valley, it's a management sim in which you bury corpses rather than grow crops. Starting as a lowly gravedigger, you repair and tend your graveyard, gradually working your way up the church ranks until you can perform memorial services and other duties, while making a side earner by selling corpse flesh to the local innkeeper to bake in his pies.

The story seems a little off from the start though. See, you're not just any old graveyard keeper. You're a regular fellow who was tragically killed in a car accident, and now you've been assigned the job as graveyard keeper in the afterlife. Why the afterlife needs a graveyard is a question the game conveniently evades. Anyway, it's up to you to bury the bodies that are brought to you by a talking donkey from the local town, while you search the local area for a witch to help you get back to your regular life.

It's up to you to bury the bodies that are brought to you by a talking donkey

It's all a bit weird and unnecessarily convoluted, which sums up the game as a whole. Play is dominated by a labyrinthine crafting system, where creating a wooden cross, one of the most game's most basic items, requires half a dozen resource types, several different types of workstation (which also have to be crafted) and multiple skills that need to be unlocked. Also, you only have a limited amount of energy, which needs to be refilled either by sleeping or eating food (which, you guessed it, has to be crafted). It took me five hours to complete the first objective, which is to basically tidy up your graveyard a bit.

It's difficult to tell whether the developer struggled to find the necessary depth in the act of graveyard keeping, or wanted to appeal more to the Stardew Valley crowd, but an awful lot of Graveyard Keeper is dedicated to doing jobs other than graveyard keeping, such as farming, cooking, fishing and doing quests for the local townspeople.

It's a shame because, when you finally get around to keeping your damn graveyard, there are some interesting and fun ideas. The corpses that arrive for you to bury are divided between saints and sinners. Burying saints improves your graveyard's reputation, while burying sinners lowers it.

With only limited space in the graveyard, you want to be burying saints, while dealing with sinners in other ways, such as burning them, throwing them into the river, or dissecting them and using the body parts for alchemy and other unsavoury practices.

This should be the kernel around which Graveyard Keeper builds its simulation. Instead, it goes off on these bizarre mechanical tangents that only serve to tank its own, potentially superb premise.

RICK LANE

OVERALL SCORE
37%

/ VERDICT
Beware Graveyard Keeper, for what lies beneath isn't what's written on the headstone.

RICK LANE / THE ENGINE ROOM

Frozen Synapse 2

Rick Lane speaks to Ian Hardingham about the tech behind Mode 7's cyberpunk strategy sequel

Frozen Synapse is one of the most inventive strategy games of recent years. Released in 2011, it's a top-down tactical shooter in which players (or the player and AI) control a squad of special forces units. During a turn, each player makes separate plans about how they will move their agents, but the resolution happens simultaneously. This setup results in an intense psychological duel of planning, bluffing and second-guessing, as players attempt to counter as many of their opponent's potential moves as possible.

Above: In FS2's combat, turns are taken simultaneously, meaning you have to anticipate your opponent's moves

In many ways, it's a perfectly distilled strategy game, and therefore a hard act to follow. Nonetheless, its developer had a pretty ambitious notion of where it could take a sequel. 'The very first thing that I thought about was simply: "How are we going to make a city? And how are we going to make the levels be faithful and accurate to the city?"' says Mode 7's co-founder Ian Hardingham.

Released last month, Frozen Synapse 2 takes the tense combat scenarios from the first game, and places them inside a large, dynamic cyberpunk city in which roughly a dozen factions compete for power. Inspired by games such as XCOM: Apocalypse and Alpha Centauri, Mode 7 wanted to enable players to come up with their own plans and objectives for winning the game. 'One of the things that excited me most was being able to take all of this information – this data from the city – and use it to make really interesting levels,' says Hardingham.

Achieving this ambition required a massive expansion of the original game, and a whole bunch of

technological updates and additions to the aging Torque engine Mode 7 uses. The expansion included the ability to generate a cityscape, more complex level generation for its combat scenarios, significant updates to the existing AI system and the introduction of a second, entirely new AI system for the city itself.

Mode 7 began this process by sourcing a city. Frozen Synapse 2's metropolis of Markov Geist is generated using a third-party tool built in Python. Currently, there's only one city in the game and its geometry is fixed, but Mode 7 plans to add more cities and, if possible, the ability for players to generate their own ones. Yet while the skyline is static, the function of buildings – whether they're a bank or an apartment block and so on, changes for every game, as does the starting locations for the many factions vying for supremacy.

The city AI recalculates all its moves each turn, enabling it to respond to short-term events

Although the city geometry is static, building functions and faction spawn locations are randomly generated

But that's only half the story. Mode 7 wanted players to be able to enter combat scenarios anywhere in the city, and have the game generate a level that resembled that location. 'Obviously it takes the core geometry from the city,' Hardingham says. 'But in terms of having a lot of variability, I knew we were going to be combining procedural room and building generation with what I call "background generators" – stuff such as the trees and the car parks. And it does some interesting, Photoshop-esque ways of combining it all to make something that looks different every time.'

Mode 7 had this feature functioning early in development, but when the developer let the public play the game at conventions, the team discovered that players didn't realise the combat zone matched the location inside the city. 'I was like: "I worked my ass off, doing this – it was really hard!"' Hardingham says. To resolve the problem, Hardingham worked with Mode 7's graphics programmer to hack together a trick whereby, when a mission began, the camera would zoom down from the cityscape into the building or road intersection where the mission was taking place.

'In terms of the zoom-in, the city view and mission view are in

Hardingham estimates there are around 5,000 buildings in the city, any one of which can form the basis for a mission

literally different coordinates systems; they're rendered in different ways,' Hardingham explains. 'When we have to start the zoom-in, we take the mission, which is the size of a tiny part of the city – so small that you wouldn't be able to see it from the city view – and we have to set a bunch of DirectX stuff to literally scale it up. Getting the maths of that is incredibly annoying.'

Alongside creating this grand-strategy metagame, Mode 7 also made several alterations to the tactical combat, adding new units, and creating the option for longer turns that play out all planned movements, rather than five-second intervals. There's also a special targeted aiming mode inspired by Counter-Strike. 'As a Counter-Strike player, you can choose to aim at this very specific doorway where you have great access, or you open up your field of vision and you see everywhere with your eyes, but you're much slower.'

The tactical side of the game also received a substantial visual overhaul. 'When you go back to Frozen Synapse 1, it's really old-school; it really looks like a DOS game,' Hardingham says. 'Our lead artist actually used Unity to prototype the graphics. He made it look how he wanted it to look in Unity, which obviously has much better artist tools than our creaky old Torque tech, and then we got our graphics programmer James to port it across.'

Beyond adding the city, the most crucial changes made by Mode 7 involve the AI. While the original Frozen Synapse made its name as a multiplayer game, Frozen Synapse 2 has a much stronger single-player emphasis, so it was crucial that playing against the AI was fun and challenging. 'The truth is that Frozen Synapse's AI wasn't amazing,' says Hardingham. 'It was quite boring to play against [the AI] – it would turtle far too often.' In case you're not up on your gaming lingo, to 'turtle' means to retreat into your metaphorical shell, concentrating on defence rather than going for all-out offensive assault.

By comparison, Frozen Synapse 2's AI is much more advanced. 'It simulates an awful lot of things that a human might do. It works out how to defeat all of them, chooses which plan defeats the most and then sooner or later it rolls a dice to choose one.' As well as being smarter, Hardingham also designed it to be more fun to play against the new AI. 'If it works out that it's just completely screwed and it's going to die, instead of hiding in a corner, which is what it did in the first one and is boring, it just switches to Rambo mode and runs out shooting.'

And that's just the tactical AI. In addition, Mode 7 had to create a secondary, overarching AI system to control the city's many factions, ensuring that they could make and execute plans, and alter them based on the evolving game state. 'The key thing is that, every time it thinks, it redoes its entire plan,' Hardingham says. 'To make the task of building a strategy game AI system easier, what you really need is for the AI to be able to make all its decisions at one snapshot in time.'

FS2's clever zooming gimmick, which shows players the transition from city to combat, took several weeks of coding to perfect

Frozen Synapse 2 was a long time coming. It wasn't a troubled project, but it was a very ambitious one from a team of Mode 7's size, which is inevitably going to lengthen development.

'Really, it's about gameplay iteration, and that's always what takes time in these projects. It's just about getting all these lofty ideas into something that's fun to play,' Hardingham says. 'The game you see is actually remarkably faithful to the original vision, especially for a game that's taken significantly over three years to make.' CPC

REAL-TIME RAY TRACING EXPLAINED

Will real-time ray tracing be the next big thing in gaming graphics, and how exactly is Nvidia achieving it? Gareth Ogden catches some rays and comes out all shiny and reflective

Nvidia has never been one to undersell its own achievements, and in many cases, deservedly so; the company has arguably led PC gaming graphics pretty consistently for more than a decade. However, for the GeForce RTX-series announcement (see p20), the hyperbole went into overload as Nvidia threw around phrases such as 'a historic moment in computer graphics'. and 'Computer graphics will never be the same again'. Nvidia even described real-time ray tracing as 'The Holy Grail'. But what is ray tracing, and is the hype really justified?

Top: Epic Games has shown off a real-time ray tracing demo featuring Captain Phasma from the new Star Wars movies

Before discussing ray tracing, it's helpful to cover how computer graphics are generated now, which is through a process called rasterisation. This process involves generating 3D objects from a mesh of triangles, otherwise known as polygons.

These triangles, along with their associated colour, texture and positional information, are then converted into pixels – the 2D dots that make up the images you see on your flat monitor. These pixels can then be further processed, or shaded, to simulate more sophisticated lighting or material effects. All current GPUs

have dedicated hardware to perform these functions.

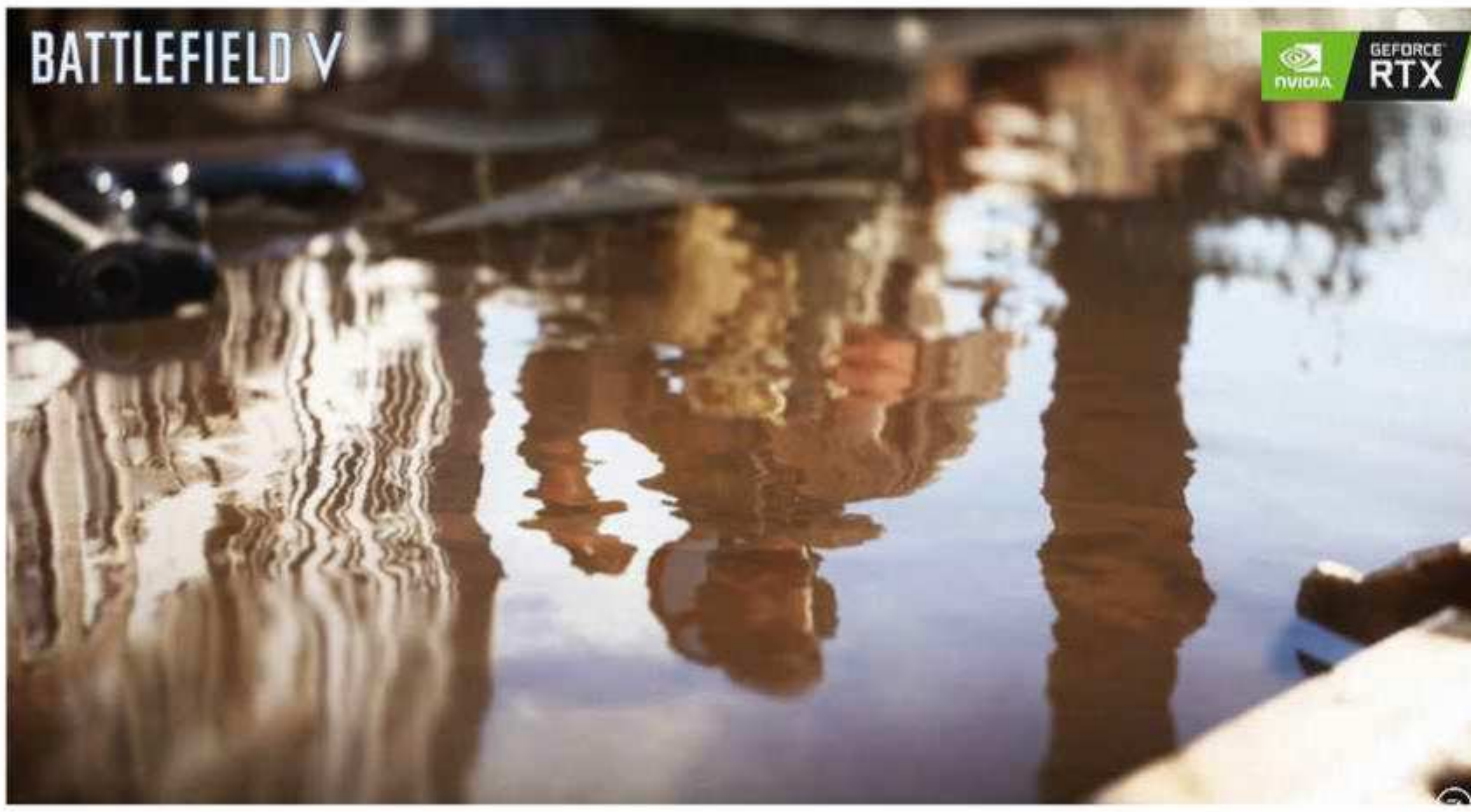
What's great about rasterisation is that it's very well suited to parallel processing, which is why modern GPUs are designed with thousands of stream processors (called CUDA cores in Nvidia GPUs), which are specifically designed to accelerate rasterisation. Nvidia and AMD have both become very good at accelerating this process in their current GPUs, to the point that a single GeForce GTX 1080 Ti can even achieve the magic 60fps frame rate at 4K in many modern games.

However, while modern games such as Battlefield 1 or Far Cry 5 look amazing, a lot of this magic is smoke and mirrors. The graphical effects that appear on-screen, especially lighting effects, are essentially sophisticated simulations of the real world, based on complex algorithms that produce results that look good, but aren't necessarily physically correct.

A good example of a limitation of rasterisation is screen-space reflections, where the rendered scene in a game is used to provide reflection information. The problem is that any object that isn't visible in the scene, as viewed from the camera (your eye or viewpoint as the player), can't be reflected in the scene.

For example, if there's a light source (such as a fire) that isn't visible in the scene, the light from this source won't be reflected in objects in the scene, such as the door of a car, or the metallic parts of your weapon.

Likewise, if there's a mirrored surface behind an object, it would be unable to reflect the rear of an object in the foreground, because the rear of the object isn't visible in the screen space. Getting around these limitations requires extra work and effort on the part of the developer and the results are often inaccurate, or too computationally intensive to include, and so are omitted.



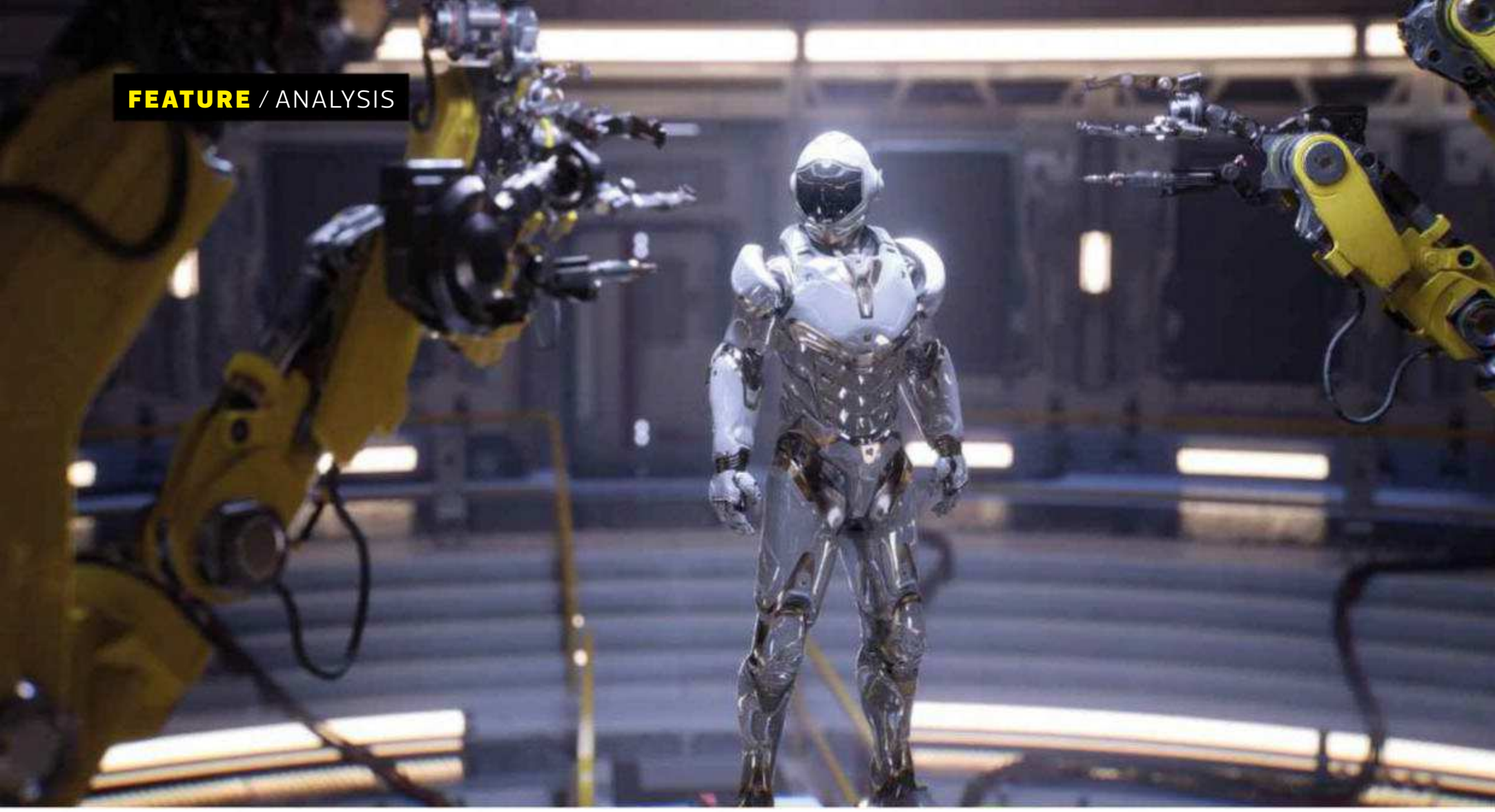
Nvidia's Battlefield V demo shows objects outside the scene being reflected in water, as well as in a soldier's eye

Get real

Ray tracing is the process of simulating the physical behaviour of light as it travels through a scene and interacts with objects in the scene.

Think of a light source and then imagine splitting up the light emitted from this source into millions of individual rays of light. Each one of these rays travels from the source into the scene, such as the room in which you're sitting right now, interacting with objects in the scene.

Whenever a ray intersects with an object, it could be reflected (causing additional rays within the scene) or refracted through glass, scattered and so on, depending on the surface of the object. It could also be blocked by an object, resulting in a shadow. The ray continues to bounce around the scene in this way, picking up information along the way that determines its final colour, until it exits the scene completely or strikes the camera (your eye). This process is called indirect lighting, or global



Shiny!

illumination, and is computationally expensive to simulate.

Unlike rendering, which is more like an artistic impression of how the scene looks – albeit using physics to get close to reality – ray tracing is a physically accurate simulation of the scene, to the point where it could be considered photo-realistic. It's for this reason that ray tracing is used extensively in the film industry to create the amazing CGI effects we see in movies such as Star Wars, the Marvel Cinematic Universe, Jurassic World and so on, although there are differences in the way ray tracing is employed in movies compared to games (see Ray tracing in movies, p89).

NVIDIA WOULD STILL NEED A PETAFLOP-LEVEL GPU IN ORDER TO RENDER IN REAL TIME

Ray tracing is actually nothing new in computer graphics. If you're as old as me, you may remember messing around with ray tracing as far back as 20 years ago, or even longer. I recall running POV-ray on my Intel 33MHz 386SX and marvelling at the crisp, 320 x 200 resolution images it produced, after several hours of processing.

These early experiences with ray tracing hint at why it has taken so long for the technique to reach the point where it can be used in games. Put simply, the computational resources it requires are enormous. Nvidia's 10-series GPUs have a raw computational performance that can be measured in teraflops, with one teraflop equivalent to one million million (10^{12}) floating-point operations per second (FLOPS).

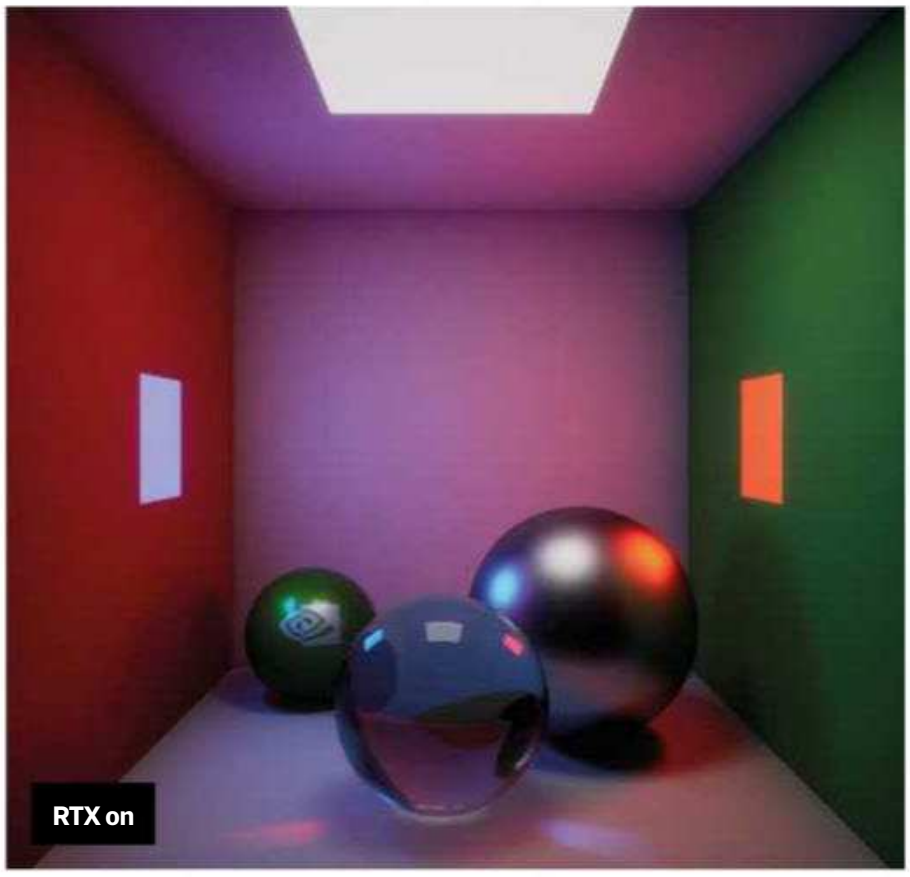
However, Nvidia explained that it would require a GPU that performed in the range of several petaflops, or several thousand million million (10^{15}) FLOPS, in order to perform real-time ray racing using this architecture. Nvidia's rate of technological advancement already vastly outpaces Moore's Law, with its GPU tech advancing at a rate of 1,000 times every ten years, but even if the company could sustain this rate of advancement, it would take another ten years to develop a GPU in the petaflop range. So how has Nvidia achieved the feat of real-time ray tracing a decade earlier?

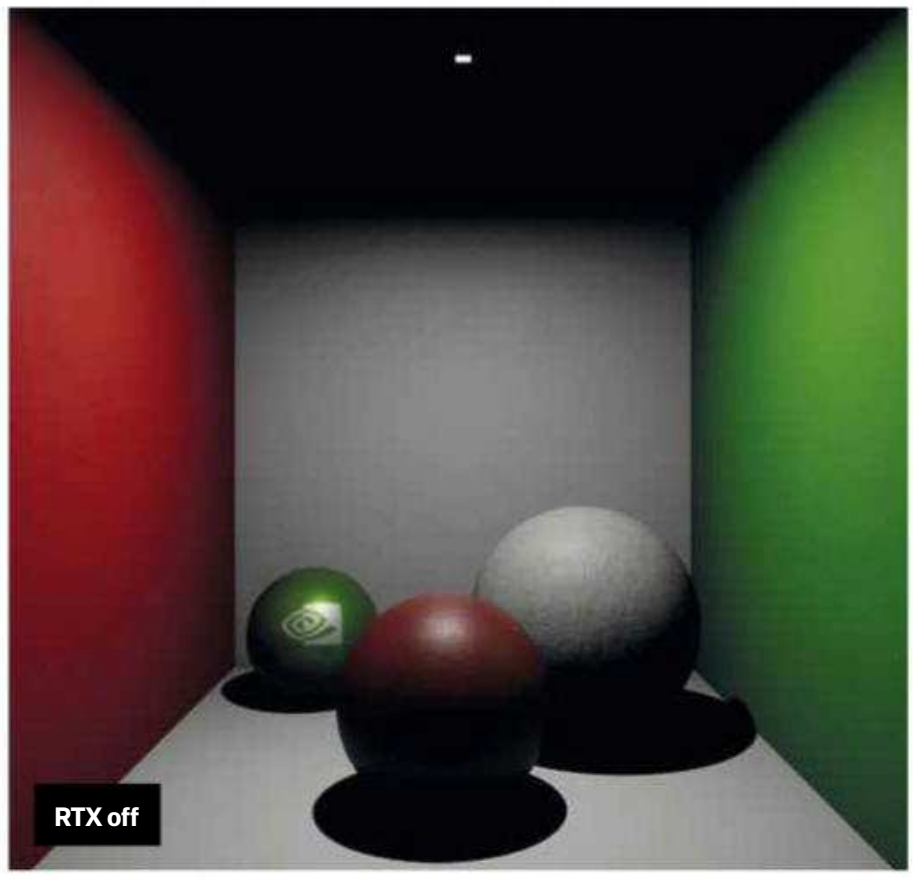
Hybrid rendering

The first key point is that the RTX GPUs aren't rendering entire scenes using ray tracing. Instead, Nvidia is doing what's called Hybrid Rendering, where traditional rasterisation is used for the majority of the scene, alongside ray tracing for lighting and shadow effects in particular. As the hardware advances, conceivably more of the scene could be ray traced, but the efficiency of rasterisation coupled with the performance budget required for ray tracing means this Hybrid Rendering approach is likely to be the norm for years to come.

Another difference is that the ray-tracing process used by Nvidia is different to the method we described earlier, where rays are traced from the light source until they exit the scene or hit the eye. Instead, Nvidia is taking advantage of the Principle of Reciprocity, which states that the physics of a light ray travelling in the reverse direction, from eye to light source, is the same as if travelling from source to eye.

Specifically, Nvidia's approach is based on work by a computer scientist called Turner Whitted in 1979, which described an algorithm called Multi-Bounce Recursive Ray-Tracing, where rays originate from the eye and travel a reverse path through the scene back to the light source. Because the vast majority of the light from the source doesn't reach the eye, this process greatly improves efficiency by essentially only casting rays that actually contribute to the final scene. Any computer scientist that can come up with such a visionary approach to ray tracing would clearly be a valuable asset to a computer graphics company, which is why it comes as no surprise that Turner Whitted is now a researcher working for Nvidia.





Enabling RTX in this image makes a huge difference to lighting, reflections and shadows

However, even by using Hybrid Rendering and employing a recursive ray-tracing algorithm, Nvidia would still need a Petaflop-level GPU to render in real time, so the next step towards making real-time ray tracing possible was to come up with an entirely new GPU architecture, which Nvidia says has been ten years in the making.

Architecture is the lever

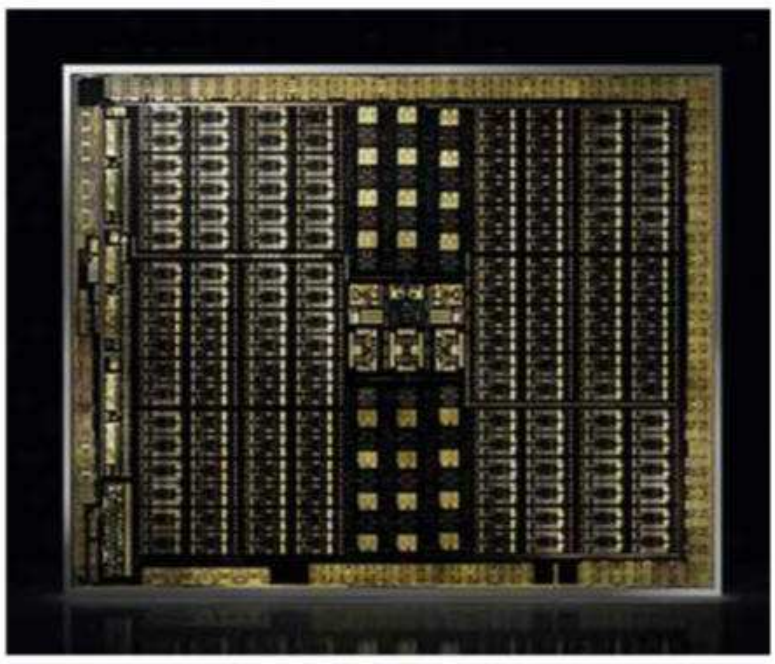
In fact, Nvidia's whole ray-tracing system is far more than just hardware, but an entirely new platform called RTX – a combination of brand-new GPU architecture with a raft of supporting software, including SDKs, libraries and so on.

On the architecture front, the RTX platform uses GPUs based on Nvidia's Turing architecture, which has been specifically designed for Hybrid Rendering. Nvidia described Turing as its greatest leap since developing CUDA. It's certainly a beast of a GPU, with the top model containing 18.9 billion transistors and three new processors, two of which are specifically geared towards ray tracing.

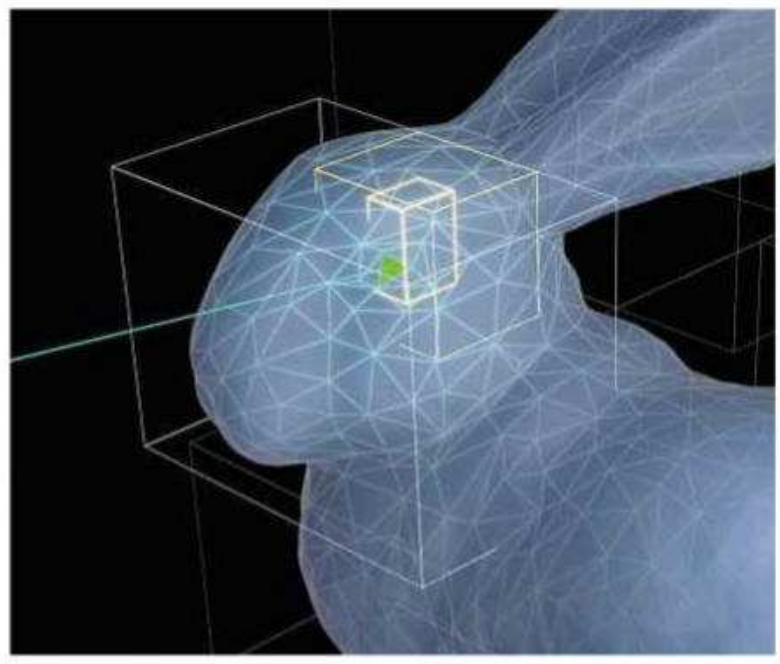
The RT Core, as the name suggests, is designed to accelerate specific ray-tracing functions. One such function is calculating ray-triangle intersections, which is essentially where a ray hits a triangle in the scene. Another function is BVH Traversal (more on this later), which increases the efficiency of ray tracing by reducing the number of rays that need to be cast.

Improving efficiency is paramount, because the performance needed to test and discover which triangle out of the millions (or hundreds of millions) of triangles with which the ray intersects is precisely the reason why real-time ray tracing has been impossible in the past. Because of the geometric complexity of the scene, it would require millions of rays to be cast, making real-time gaming impossible. Instead, Nvidia uses a Bounding Volume Hierarchy (BVH), which is a common acceleration structure in ray tracing. Nvidia's CEO, Jensen Huang, described this process as 'binning', which is a good way to think about it.

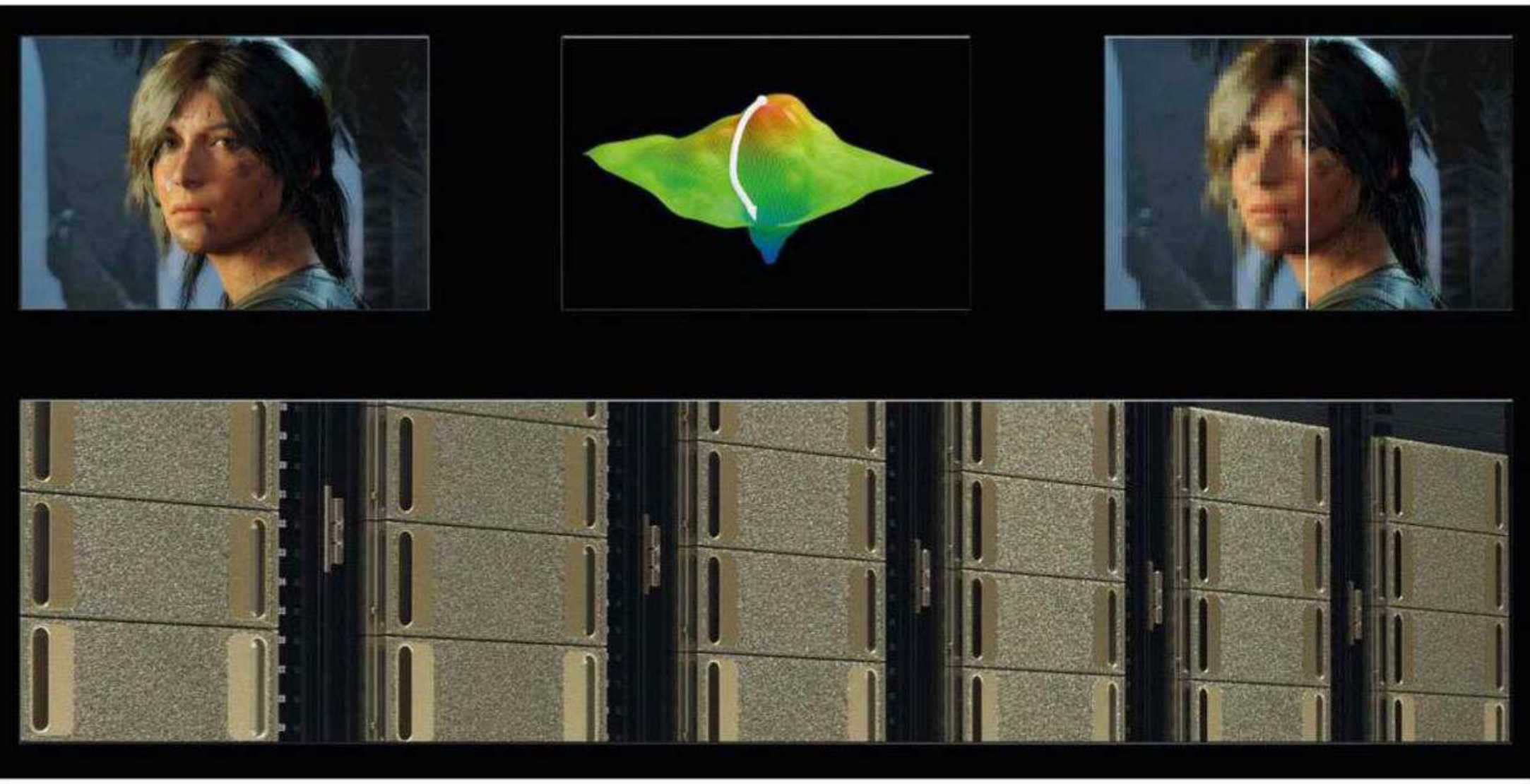
Essentially, when using a BVH structure, the entire scene is split up into boxes, which are considerably larger than individual triangles, then inside each large box is a number of smaller boxes and so on, until you get



Nvidia's Turing architecture is a beast, containing 18.9 billion transistors, and two new processors specifically geared towards ray tracing



When using a BVH structure, the scene is split into boxes containing smaller boxes and so on until you get down to a set number of individual triangles



The RTX Tensor processor uses neural networks and AI to improve image quality

down to a set number of individual triangles. This structure means that, when a ray cast into a scene interacts with one of the larger bounding boxes, all the other large bounding boxes can be ignored, and the testing process can concentrate solely within the space of the intersected bounding box. Testing then continues by figuring out which of the smaller bounding boxes within the larger box is intersected, and so on until the actual triangle that's intersected is discovered.

However, while this BVH acceleration structure is enormously faster than casting millions of rays in order to intersect individual triangles, it still requires an enormous amount of processing power. Nvidia talks about this performance in terms of 'Giga Rays per second' and stated that the Turing GPU is capable of ten Giga Rays per second, compared to 1.21 Giga Rays per second for the GTX 1080 Ti – an almost ten-fold increase.

Nvidia's RTX tech demos look amazing, but it needs support from lots of real games too

Tensor moments

Even with the dedicated ray-tracing performance offered by Turing's RT Core, there is still a hard limit on the number of rays that the GPU can manage in order to maintain a smooth frame rate. BVH Traversal helps to reduce the number of rays cast, and Nvidia is also limiting the number of samples per pixel. That's great for improving performance, but has the negative side effect of harming image fidelity. The fewer the number of rays and samples, the noisier the final result looks.

To get around this problem, Nvidia has designed what it calls a Tensor Core, which is perhaps the most impressive part of the RTX platform. The Tensor Core is essentially a deep learning or AI processor that can take the noisy image and correct it. This 'de-noising' is possible because the Tensor Core has access to pre-trained deep neural networks (DNNs), which will be included in Nvidia's drivers.

These trained networks are created by feeding a supercomputer with a huge number of high-fidelity images and then training it to upscale or correct lower-fidelity images. Over time, the neural network learns how to correct the low-res or noisy images, to the point at which even the Turing GPU's sparse ray-raying approach, using a limited number of rays and samples,

can be made to look accurate and closer to the reference image, or 'ground truth' as it's known.

Nvidia is also using this technique for anti-aliasing, with what it calls Deep Learning Super Sampling (DLSS). This real-time image enhancement also requires a huge amount of processing power and Nvidia stated that it would require ten GTX 1080 Ti GPUs to keep up with the Tensor Core processor in the Turing GPU.

Graphics will never be the same again

There's no question that Nvidia's Turing GPU and RTX platform is a significant leap forward for computer graphics, and the combination of ray tracing and deep learning will allow for physically accurate, photo-realistic in-game lighting effects that were simply impossible on previous-generation hardware, which relies on rasterisation alone.

As with any new technology, however, the success of RTX and real-time ray tracing relies entirely on game developer support. If no games support the Turing GPUs' advanced features then a significant chunk of its 18.9 billion transistors will go unused. Thankfully, Nvidia has very strong relationships with developers, and although it hasn't always been entirely successful at getting its unique GPU features used extensively in games, this time it really doesn't have a choice – without ray-tracing support, there's really no incentive to upgrade from GTX to RTX.

At Gamescom 2018 launch event, Nvidia highlighted 21 titles that will feature RTX support, including Battlefield V, Shadow of the Tomb Raider, Metro Exodus and Mechwarrior V: Mercenaries. That's not a bad start, but with GeForce RTX 2080 Ti cards from board partners, such as Asus, Gigabyte, MSI and EVGA on pre-order for £1,200 or more, the number of games will need to increase quickly to make early adoption worthwhile.

We also currently need to wait for the next Windows update before Windows fully supports real-time ray tracing in DirectX. Shadow of the Tomb Raider has already been released for Windows, but it currently contains no ray-tracing features, with Square Enix saying they will be enabled in a future patch, presumably following the next Windows update, which is scheduled for release later in October.

These are early days for real-time ray tracing and as Nvidia (and AMD) continue to develop higher-performance architectures and refine the crucial software components, support for Hybrid Rendering will increase, and eventually filter down into GPUs with more palatable price tags. So while RTX is a great first step, it will take many years for ray tracing to become a common component in all games, and one that even mainstream gamers can experience.

Will graphics never be the same again? Time will tell, but Nvidia has certainly shone a ray of hope on the gaming industry, and we're certainly looking forward to there being a bright future for real-time ray tracing. CPC

Some frames in Coco used as much as 120GB of memory while rendering

Ray tracing in movies

Ray tracing has been used extensively in the movie industry for decades, not only in animated movies, but also to add CGI (computer-generated imagery) effects to live-action movies. Ice Age was a groundbreaking example in 2006, where ray tracing was employed to accurately simulate how light scatters off the animals' fur, with each piece of hair casting accurate shadows.

In most respects, ray tracing in movies is used to create the same global illumination, or indirect lighting effects as the RTX simulates in games, such as enabling more realistic reflections and shadows, including accurate shadows from ambient lighting in the scene. The key difference between movies and games is fidelity – put simply, the quality and accuracy of the output for movies is vastly higher than in games.

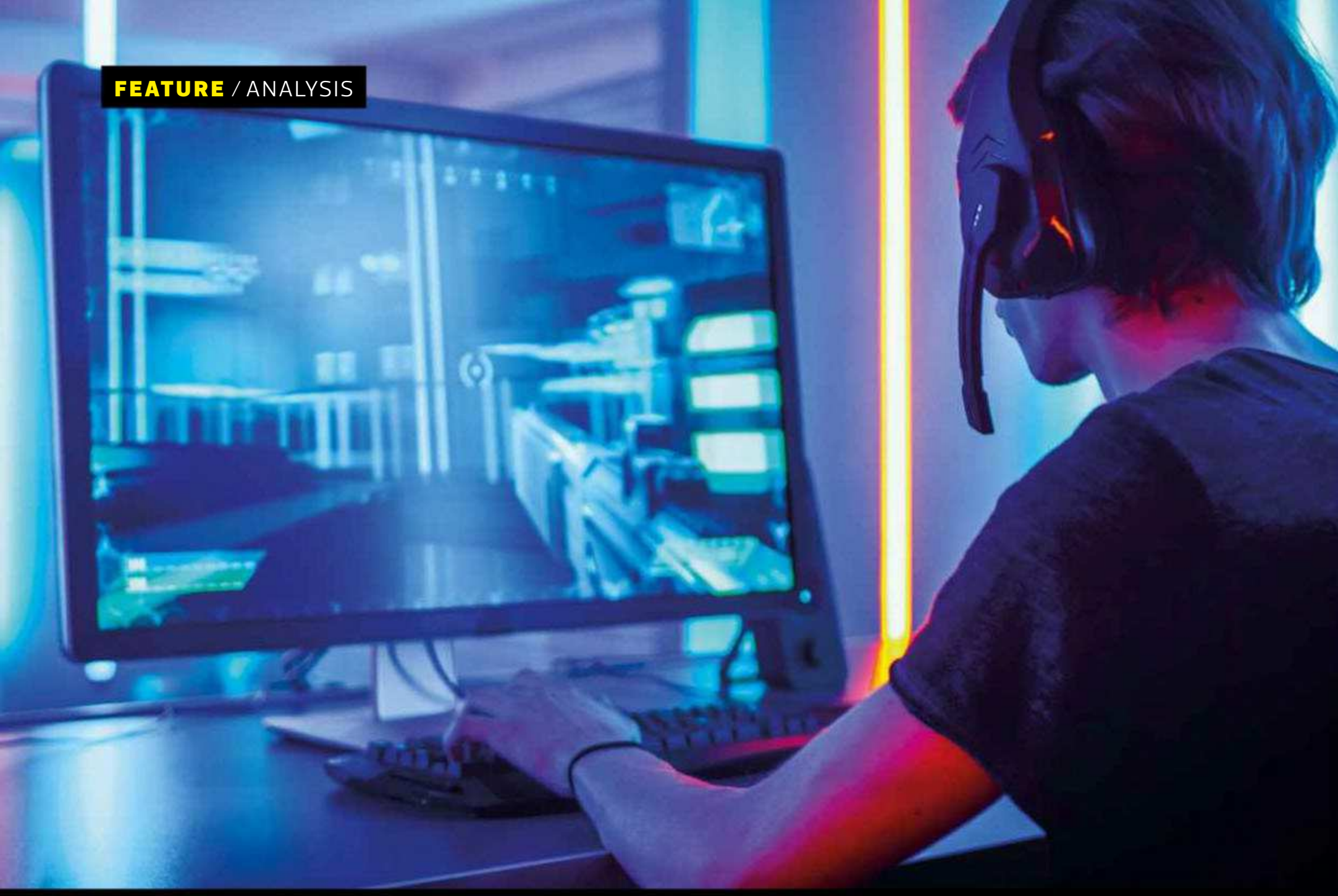
Of course, unlike movies, games are played in real time. For ray tracing to be employed in games, each frame needs to be drawn in under 17ms to hit 60fps. Even with the latest GeForce RTX 2080 Ti, sacrifices have to be made in order to achieve the desired frame rate within the available hardware performance budget. Even so, by using the Turing GPU's sophisticated Tensor Cores, Nvidia is able to produce surprisingly accurate results, even from the limited number of rays and samples with which they're able to work.

The movie industry doesn't have this problem, because it can afford to spend hours rendering each frame. For example, for the 2017 Disney Pixar movie, Coco, the render time was 50 hours per frame. Interestingly, Pixar's use of 'hours per frame' is slightly misleading, because it doesn't mean that each individual frame took 50 hours to render, but rather that it would require the equivalent of 50 single-core PCs to render the frame in one hour, if it were not being rendered on Pixar's own render farm. Quite why Pixar talks about render time in this way is a mystery, but perhaps it prefers to keep the real performance of its render farm a secret.

Regardless of how render times are calculated, the movie industry is able to work with vastly more complicated scenes than can be rendered in real time. This allows the animation studios to build their scenes with incredibly complex geometry and a huge number of light sources. For example, Coco featured scenes with up to 100 million objects and up to 8 million light sources.

Considering the staggering complexity of CGI movie scenes, it's not surprising that the memory requirements are equally stratospheric. For Coco, the average memory use was 35GB per frame and some frames used as much as 120GB. These figures make the 11GB of GDDR6 memory on a GTX 2080 Ti seem rather paltry in comparison.

So, while Nvidia's achievement of making real-time ray tracing a reality is certainly a major milestone in PC graphics, it will be a very long time before we can play games with movie-quality visual effects.



CLOUD GAMING [TESTED]

After the fall of OnLive, multiple developers have taken up the cloud gaming mantle, but is there a viable future in the technology, or are these companies living on cloud nine? Rick Lane goes hands on with the latest cloud-gaming systems

Cloud gaming was once heralded as the future of the industry. Why spend hundreds or even thousands of pounds on a new gaming PC every few years, when you could just stream any game regardless of its system requirements straight to your monitor, TV or laptop? It's more convenient, more mobile and, if you're a regular player of all the latest games, much more cost-effective. Even now, a 'Netflix-for-games' style service seems like an appealing business venture.

Then came OnLive, the first ever cloud-gaming service. It's still the most famous, or perhaps we should say infamous. Instead of proving the viability of cloud gaming, OnLive demonstrated that streaming games was significantly more difficult than streaming video. Whereas a small delay between pressing play on a video and the video actually playing is a small inconvenience, gaming requires a far greater number of player inputs, and a similar lag between each of them would kill any game dead. Especially if it was an online multiplayer game.

Said input lag varied greatly between games on OnLive's service. What's more, the image quality of OnLive simply couldn't match that of a locally powered PC. Most importantly, though, at that time, it couldn't gain the huge customer base it required, and ended up losing money on a massive scale. After suffering huge layoffs in 2012, OnLive

struggled on until 2015, when the company's patents were acquired by Sony, which has since debuted its own cloud-gaming service PlayStation Now.

While the fate of OnLive may have put paid to cloud-based PC gaming for a while, it appears the dream didn't die completely. In the past year, multiple companies have launched new cloud-based gaming services for the PC. They range from the indie game cloud service Jump, to the mighty Shadow, which streams a powerful gaming PC to a wide range of supported devices.

We decided to test four of these systems, looking at how each of them works and the quality of service they provide, to see if any of them offer a viable future for cloud gaming. We tested the services on two very different systems. The first is an aging gaming rig, running Windows 10 with a Core i5-3530K, an Nvidia GTX Titan graphics card and 16GB of RAM. This system is also connected to a wired broadband connection with a 50Mb/sec download speed. In short, it's a more than ideal home system for using a streaming service.

The second system is a Lenovo 100s Netbook connected via Wi-Fi. This system is entirely unsuited for conventional gaming, but one of the primary aims of cloud gaming is to free players from hardware constraints, with the ultimate goal of letting you play anywhere on any system as long as you have a sufficient broadband connection, just like Netflix with video.

Shadow works impressively well with Doom, offering image quality that's largely indistinguishable from that of a local PC

SHADOW – THE CLOUD-BASED PC

DEVELOPER Blade
PRICE £26.95 per month
WEBSITE https://shadow.tech

Most cloud-gaming services operate using a Netflix style format, providing users access to a range of curated games in exchange for a monthly fee. Shadow is different.

Instead, it streams a powerful desktop PC to your device. The service works through Blade's Shadow app; once you're subscribed, this is downloaded onto your device (supported operating systems include Windows, Linux and Android, with support for iOS in the pipeline). Through this app, Shadow connects your PC to another PC based in Paris, which is then streamed back onto your monitor.

Essentially, you're given access to a brand-new, clean gaming PC. In fact, Shadow requires you to go through the first-time setup for Windows 10, which means spending around ten minutes being pestered by Cortana. After that, however, it's yours to browse the Internet, watch online TV or download Steam and install games. Indeed, if you're operating Shadow in full-screen, it's just like using your PC at home.

While you can use Shadow for any purpose, the service is geared primarily towards gaming. The PC that Shadow streams to your device is certainly powerful, although more so in some areas than in others. Headlining the show is the graphics card, which is an Nvidia GTX 1080 equivalent (Nvidia doesn't allow commercial use of actual GTX 1080s, but whatever GPU hardware Shadow is using undoubtedly delivers on performance). The CPU is rather less ferocious, being a quad-core Intel Xeon with Hyper-Threading, but with only a 2.3GHz clock speed. The Shadow PC also has 12GB of DDR4 RAM.

The weakest point of the Shadow PC is storage, with a paltry 256GB on offer. Given that most of today's big-budget games will easily gobble up 30GB of space, with some edging toward 100GB, you won't be able to store many games at once.

Fortunately, the pressure on storage is alleviated by the system's whopping 1Gb/sec fibre connection, letting you download even the largest games in minutes. Indeed, while testing Shadow, Steam would download game data at a rate up to 60MB/sec. That's megabytes, not megabits.

It all sounds solid in theory, but what's Shadow actually like to use? We tested Shadow with several games, including No Man's Sky and Counter Strike: Global Offensive. Primarily, however, we used id's 2016 reboot of Doom, a fast-paced, visually stunning FPS that offers both single-player and multiplayer components.

Shadow was managing to hit frame rates over 100fps in Doom

Using the desktop's native hardware, Doom delivered a consistent 60fps average frame rate at 1080p with TXAA enabled. On the Shadow machine, the average frame rate was considerably higher, hitting over 100fps. When it came to image quality, however, the Titan machine was the sharper overall.

There were times using Shadow when a slight blurriness would become visible during play. However, there were also times when the image quality was more or less indistinguishable between the two, which is pretty impressive for what's basically a video stream.

Meanwhile, controls have an ever so slightly more syrupy feel on the Shadow machine compared with the local one, but it's a minor difference – it's nothing like enough to cause problems while playing a single-player game, even one that's as intensive and fast-paced as Doom. We also tried a few rounds of Counter Strike: Global Offensive across the stream. When Shadow is running well, it's more than playable, although we wouldn't recommend playing a ranked match with it, as that slight loss of responsiveness is nonetheless vital in a game as twitchy as Counter-Strike: GO.

You may have noticed the phrase 'When Shadow is running well' there. We tested Shadow on and off across three days, specifically over a weekend while our home network was seeing additional use, and on a Monday morning with the Titan PC as the sole user. On the Saturday, Shadow ran smooth as glass. On the Sunday, however, it was completely unusable, with all games suffering from heavy lag.

It was hard to discern the reason. We noticed that the download speed on the Shadow PC was significantly reduced to under 20MB/sec for most of the Sunday, compared to the 60MB/sec we'd received on the Saturday (which is still very fast). But the issue was affecting single-player games across the stream as well, so it's more likely that the issue was to do with increased network traffic at home, either on the local network or across the ISP (Virgin Media). On the Monday, Shadow was back to running smoothly again. Whatever the reason, though, it shows that you're not always going to get a consistent experience from cloud gaming.

A good range of games is provided that work well, including No Man's Sky

Overall, Shadow works fine on a normal desktop PC, but how did it fare in the netbook test? The answer is fairly well. Shadow itself runs without issue on the Lenovo, using the 32-bit Windows 10 version of the Shadow app. What's more, it was possible to boot up and run games via the Steam client on the Shadow machine. One advantage of Shadow being a streamed PC rather than streamed games is that it means you can adjust the native resolution of both the desktop and the games to fit your device, which was handy given the Lenovo's tiny 1,366 x 768 screen.

Seeing Doom run on a weedy netbook is quite remarkable. While it was playable, however, it wasn't seamless, suffering from a small but consistent stutter throughout the test. This issue could have been a result of the netbook's restriction to a 2.4GHz Wi-Fi band (Shadow recommends 5GHz for an ideal experience).

Alternatively, it could have been an issue on the Shadow side. This test was run on the Saturday evening, when traffic is usually at its peak. We ran a second test on the Monday, however, and experienced a similar issue. It could also be due to the Netbook processor's low clock speed. Either way, we wouldn't recommend using Shadow with a netbook, but the fact that it's even possible is impressive. A standard laptop should have no issues whatsoever playing the top-tier games, as long as you have a fast and reliable Internet connection.

That said, there are some clear issues with Shadow. The first is that, while it's powerful, it's not immediate. Because it's a remote PC, rather than streaming games from a remote server, your account has to be activated manually after you subscribe, which according to Shadow's own website can take up to five days. That's a long time to wait for access to a cloud service.

Another issue is the price of £26.50 per month, which is extremely expensive for a cloud-based service. It's over twice as expensive as PlayStation now, and almost four times the price of a subscription to Utomik or Jump. Over the course of three years, a Shadow subscription will run you roughly the cost of a new gaming PC.

There's also no free trial, and no games library with that subscription. If you want to make the most of Shadow as a gaming PC, you'll either need to own a substantial digital gaming library already, or have a subscription to another cloud gaming service.

Video compression, followed by upscaling, means PS4 games such as Bloodborne don't look as sharp as on a native PS4, but they're still perfectly playable

PlayStation now enables you to access a load of console-exclusive games from your PC

That said, Shadow's equipment is upgraded all the time, and the company has a dedicated support centre for any technical issues encountered, so there is a convenience benefit to paying that subscription price.

It also means you have a gaming PC that can be remotely accessed from anywhere, and can turn a low-end PC or a laptop into a gaming behemoth with no hardware investment required.

PLAYSTATION NOW

DEVELOPER Sony
PRICE £12.99 per month (with 14-day free trial)
WEBSITE www.playstation.com/en-gb/explore/playstation-now

No, you haven't stepped into a parallel dimension. You are seeing a PlayStation product mentioned in a PC magazine, and with good reason too. PSNow now might be a PlayStation service, but you can use it to play PlayStation games on your PC. PlayStation Now is Sony's game streaming service. It was developed using technology originally developed by Gaikai, an American company acquired by Sony three years before it also acquired OnLive. Although designed primarily for PlayStation 4 users, Sony has also released a downloadable app that can be used to play PlayStation games on PC.

Why would you want it? Well, PlayStation Now has a large library of hundreds of games released for the PS2, PS3 and PS4, many of which are either console-exclusive or PlayStation-exclusive. The library includes Uncharted 1,2 and 3, God of War 1, 2, and 3, Silent Hill 2, Red Dead Redemption, The Last of Us, Heavy Rain, Until Dawn and, perhaps most notably of all, Bloodborne – From Software's PS4-exclusive follow-up to Dark Souls.

PSNow is also the most reliable cloud-gaming service we've used. We tested both Bloodborne and Red Dead Redemption via the PC app, and encountered no significant issues of latency on our machine. Indeed, playing Bloodborne, which is a heavily twitch-based combat game, was entirely seamless. The image quality is less sharp than playing Bloodborne directly on a PS4, due to the fact that PSNow compresses the video down to 720p and then upscales it to your resolution. However, it's still more than sufficient to appreciate the gothic stylings of one of the PS4's flagship games.

That said, PSNow failed the netbook test, largely because it requires a minimum of a 2.3GHz Core i3 CPU to run. The app itself was unstable, and trying to run Bloodborne on it produced some truly horrific artefacts. A laptop should be able to run the program without a problem, however.

To use PSNow on PC, you need a PSNow subscription and a PlayStation account. You don't need to own a PlayStation 4, and you also don't need to own a DualShock controller, just any XInput-compatible controller, which includes Xbox controllers. We recommend investing in a DualShock controller, though, as PSNow games are all designed to make use of it, and they're also well built. What's more, the DualShock is also compatible with Steam.

Meanwhile, the £12.99 monthly subscription cost is fairly pricey for a streaming subscription, although not nearly as expensive as shadow. However, if you're a regular PC gamer who wants to play a few PlayStation exclusives without investing in a console, then signing up to PSNow for a few months is a fine alternative. It gets updated regularly too, so there's a good chance that more exclusive games will become available farther down the line.

UTOMIK

DEVELOPER Utomik
PRICE £6.99 per month (with 14-day free trial)
WEBSITE www.utomik.com

Utomik is probably the closest to a Netflix-modelled gaming service that you can find on the PC. For £6.99 a month, it provides instant access to a range of games through a slick series of side-scrolling menus. There's one

You only need to download 1GB of data before games such as Batman: Arkham Asylum are playable

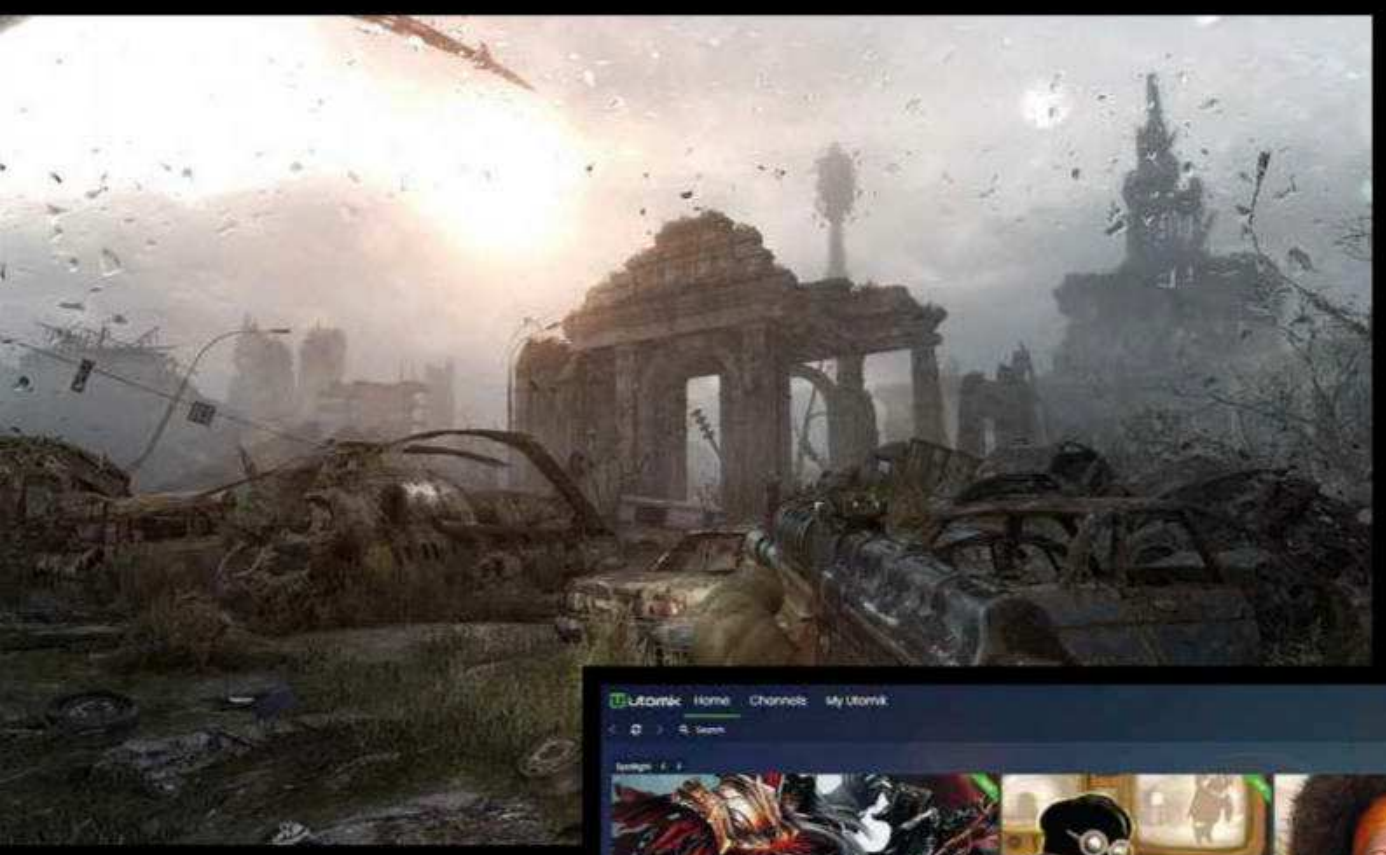
Normally, Batman: Arkham Asylum requires 8-9GB of storage space. With Utomik ,that file size is reduced to 2.79GB. Metro Last Light, meanwhile, clocks in at 5.78GB on Utomik – roughly half the size of its usual 10GB download. Utomik also offers a slightly more expensive subscription that allows multiple people to use the service at the same time.

Unlike other cloud gaming services, Utomik's focus is access to the library for a fixed cost, rather than offloading hardware requirements. Also, while file sizes are smaller, you still have to worry about storage space, while the fact that Utomik uses your system to run the games also means it's not at all portable or flexible, which is one of the main benefits of cloud gaming. Running the netbook test for Utomik would have been a pointless endeavour, so we didn't.

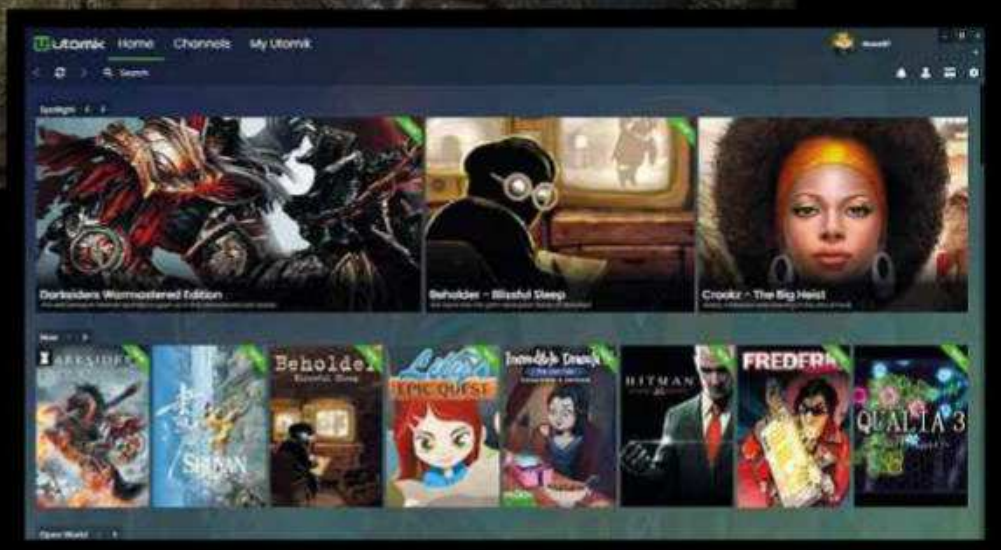
That would be fine if the library was expansive, but that's sadly not the case. There are some decent games on Utomik, such as Saints Row IV, Borderlands, and Hitman: Blood Money, but even its most notable titles are several years old, while the rest are either second-tier games or downright weird selections, such as Fabulous Angela's Wedding Disaster.

Utomik has recently promised that 20 new games will be added to the service each month, but there's no guarantee those games will be either new or even good.

In the sense that it offers a few pearls among a much larger pile of mediocrity, Utomik is a little bit like a Netflix for games, but it's hard to recommend as a service. Sure, in theory, you could boot it up on any system, but it will only run the game if you have the system requirements to do so. Utomik may look the part, but in practice, it's a long way from justifying the £7 a month subscription price.



Metro: Last Light is one of the games on offer on Utomik, although there's a notable lack of new titles



Utomik is a bit like the gaming equivalent of Netflix

major difference between Utomik and Netflix, however, which is that Utomik isn't a streaming service. Like Steam, it downloads games directly to your hard drive – it just does so in a way that lets you play them a bit quicker, while reducing their file size.

We tested Utomik by playing Batman: Arkham Asylum and Metro: Last Light. Once you choose a game to play on Utomik, it immediately begins downloading it to your machine. Once it reaches a certain threshold, which in the case of both Batman and Metro was just over 1GB, it launches the game, and then downloads the remaining game data in the background.

To be fair to Utomik, it does its job very well, providing a smooth experience with no interruptions, and it's admittedly quicker than downloading and playing a game on Steam.

JUMP

DEVELOPER Jump
PRICE £4.99 per month (with 14-day free trial)
WEBSITE https://playonjump.com

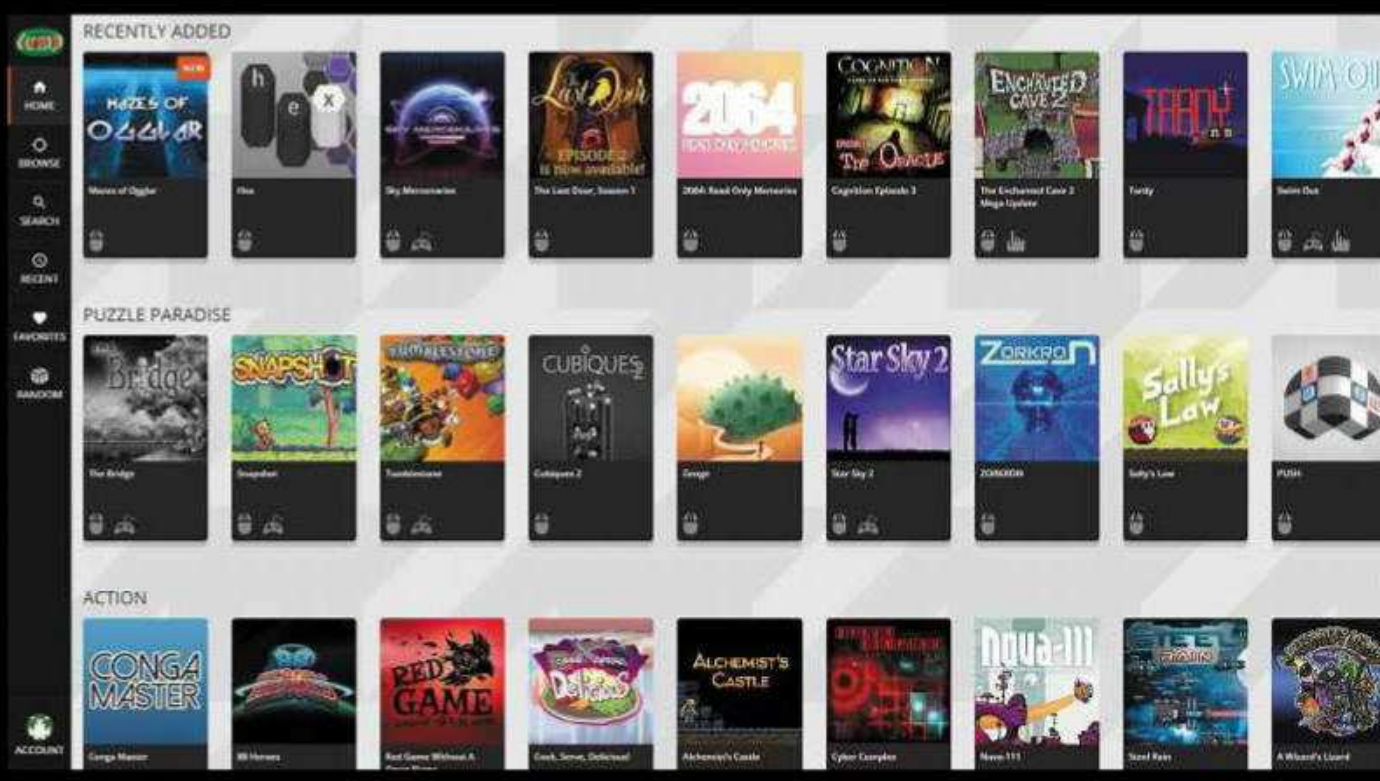
Jump is a subscription-based games library similar to Utomik, but it's dedicated elusively to showcasing weird and wonderful indie games. It's a noble sentiment, but is it worth a fiver of your hard-earned cash per month? In a word, no. Jump has the same problem as Utomik, only worse. Its emphasis on indie games means there are fewer standout titles from which to choose, while its overall offering veers far closer to 'weird' than 'wonderful'.

The technology is at least interesting. Like Utomik, Jump isn't a streaming service, but it also doesn't download the game to your hard drive, at least not all of it. Jump uses what it calls its 'HyperJump Technology', which seems to be a blend of streamed and downloaded content. In essence, Jump streams the game *content* to your PC, but downloads just enough data so that the actual computation is handled locally.

The result is an almost instantaneous playing experience. Most of Jump's games are playable in under a minute and, unlike Utomik, it doesn't carry on downloading gigabytes of data in the background. However, it's hard to tell how much of this speed is down to the 'HyperJump technology' and how much is down to the fact that most of Jump's titles are indie games with relatively small file sizes anyway. That said, one neat feature of Jump is that you can also select and play games directly in your browser.

As you'd expect, Jump games ran just fine on the Titan machine. Jump failed the netbook test, however, mainly because the Jump App requires a 64-bit system, so it won't function on older machines. We did manage to get Nidhogg running through the Jump browser on the Netbook, but it was unplayably slow. On a modern laptop or Ultrabook, however, Jump should run fine.

A handful of basic 3D games, such as Evangeline, are offered on Jump



Jump is dedicated to weird and wonderful indie games, with perhaps a larger focus on weird

Unfortunately, Jump's main problem is the disappointing games selection. Sticking purely to indie games is laudable, but even within that sphere, the selection is limited. Its most notable games include Ten Second Ninja X, Always Sometimes Monsters, and The End is Nigh.

Most of its games are 2D, although there are a handful of basic 3D games, such as Cloudbase Prime and Evangeline.

Whichever way you look at it, Jump struggles to justify that subscription fee – it's in desperate need of some bigger indie hitters, such as Super Meat Boy, Spelunky or What Remains of Edith Finch. There could be a future in the technology behind Jump, but the games on offer are so technologically basic that frankly it's hard to tell. CPC

[VERDICT]

Cloud gaming has made significant steps forwards since the unfortunate demise of OnLive, but there's still no 'must-have' gaming service. Shadow works impressively well, but it's also expensive and its appeal depends largely on your circumstances. We can see getting good use out of a remote gaming PC, but for an everyday user it's a harder sell, especially for the price. Meanwhile, Utomik is all flash and no dash, while Jump is a cool idea that's undone by its meagre collection of indie games.

Ironically, the best PC cloud-based service is wasn't originally designed for PC Gamers. PSNow is the only streaming service that combines convenience and reliability with a product you can't get elsewhere on the PC. Its streaming is rock solid and the only other option to play many of its games is to invest in a PS4.

There's one player yet to enter this game that could change the entire landscape, though, and that's Nvidia. Currently in beta, Nvidia's GeForce NOW service is said to offer a substantial improvement over any previous game streaming system, offering players the ability to stream any games they own that are supported by the service (currently 150 games are supported in total), to smaller devices.

Although cloud gaming as a whole still isn't quite ready for general consumption, it does seem to have a more viable future now. Certainly, a cheaper and more immediate version of Shadow could have enormous appeal, as could a Utomik that actually streams a larger library of games. Give it another couple of years, and cloud gaming could indeed be a viable alternative to owning a gaming PC or console.

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

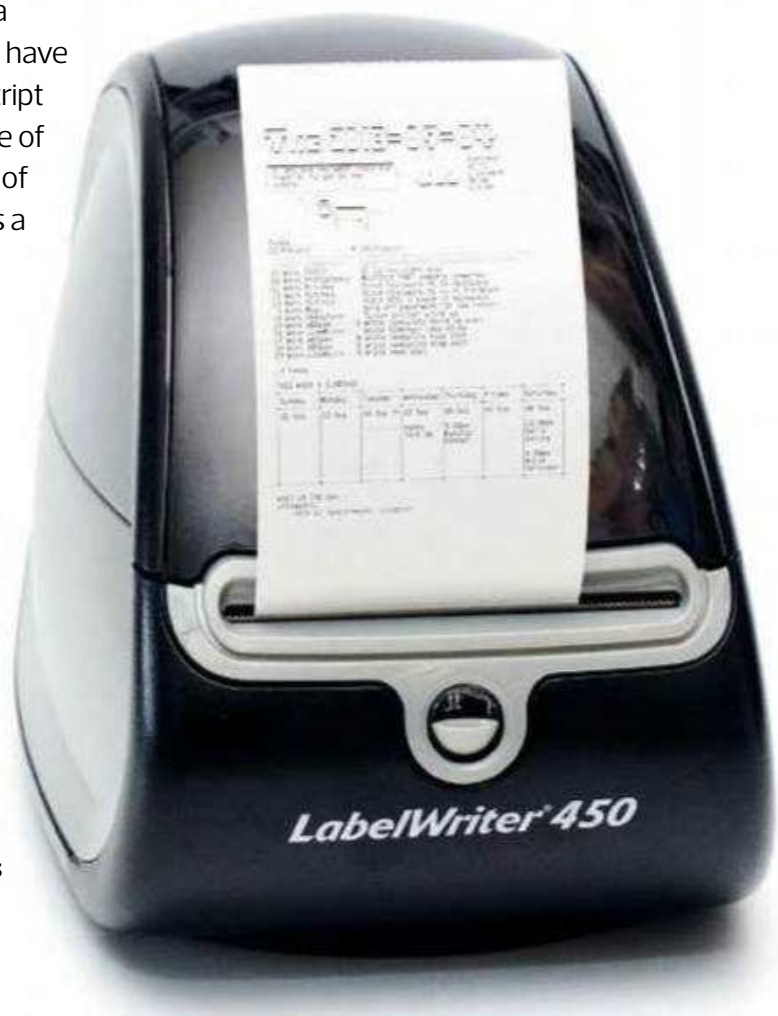
TUTORIAL

Daily schedule printer

As a freelancer it can be challenging remember to put on pants in the morning, much less remember what you're supposed to be doing all day. Previously, solutions have centred around pen and paper, but when you have a Linux machine, every problem looks like a potential shell script, and when you have a label printer, this potential shell script gets really exciting. For a given value of 'exciting' that includes small scraps of paper, anyway. This project involves a Linux machine with an Internet connection, some freely available software, a Dymo LabelWriter 450 printer, and the bizarre desire to have a teeny-tiny card with your day's schedule printed on it.

The printer

The Dymo LabelWriter 450 is, as the name implies, designed for printing labels. At its heart, though, it's a standard thermal printer. Fill it with non-adhesive name-badge stock (product code S0929100) and you have a card printer, and one that shows up in Linux as a CUPS-compatible device to which you can just throw text. It's this latter feature that makes this entire project possible. Any CUPS-compatible thermal printer will work, including continuous-feed line printers designed for receipts. Just avoid using a standard desktop printer; nobody wants a sheet of A4 thrown at them every morning.



Automatically delivered daily schedules with a talking cow and weather report? Don't mind if I do!

The tasks

The main aim of this project is to see which jobs are outstanding each day, and there's a very handy tool that tells you exactly that information: TaskWarrior. An open-source project, TaskWarrior can be installed quickly, by typing:

```
sudo apt install task
```

Adding your tasks is straightforward, once you're used to the syntax type:

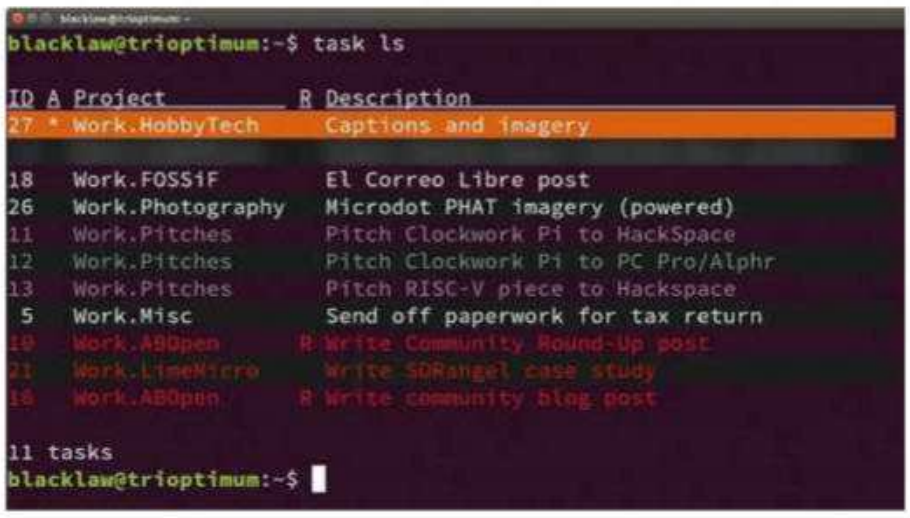
```
task add due:eod project:Work.
HobbyTech priority:H Explain
TaskWarrior
```

Listing tasks is simpler still – type:

```
task ls
```

With a simple text-based interface, the output of TaskWarrior is ideal for printing on the LabelWriter.

This symbol means the command should all be on one line



TaskWarrior is a powerful tool, once you've learned its syntax

Being able to access Google Calendar from the command line opens up new

The calendar

Tasks are one part of the information you need, but what about a calendar? You don't want to end up accidentally working on a bank holiday, after all. Here there's another tool: GCalCLI, a third-party command line interface for Google Calendar. To install it, type:

```
sudo apt install gcalcli
```

Setting it up is a little more involved, requiring you to use the Google Developer Console to set up a project with Calendar API access, then you need to authenticate with OAuth2 to get a client ID and client secret pair.

Once you've followed the instructions, getting a calendar report for the week is as simple as typing:

```
gcalcli calw 1
```

It's also possible to display only selected calendars using the `--calendar` option, if you have more than one of them linked to your Google Calendar account.

The fun stuff

Who said time management was always boring? To add some fun, let's use a couple of handy tools to bring in a randomly-selected fortune:

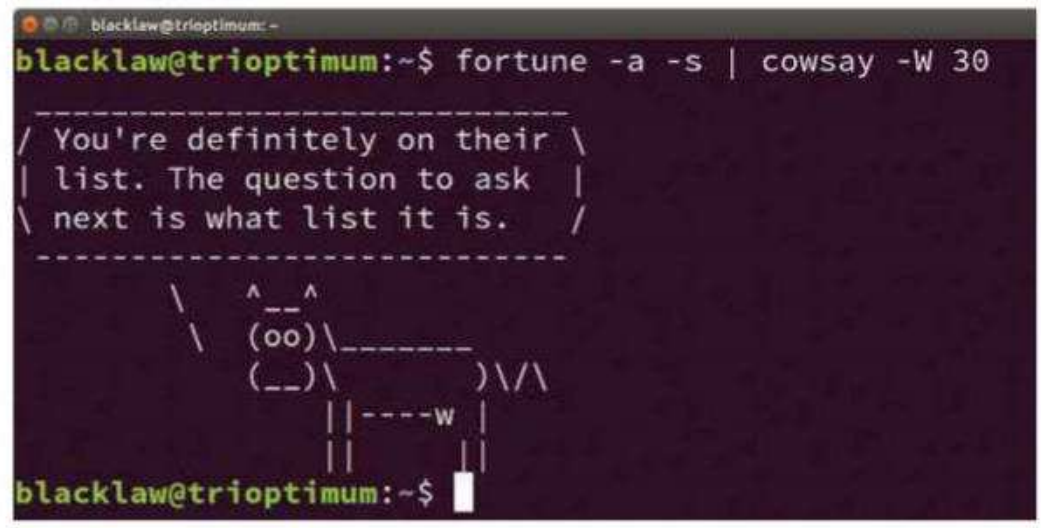
```
sudo apt install fortune cowsay
```

String the two together:

```
fortune -a -s | cowsay -W 30
```

And now you've got a talking cow! A little more sensible is a weather report, which is made easy thanks to a web-based weather service:

```
curl -s wttr.in?0QT
```



Who can resist a talking cow?

Meanwhile, pulling in a word-of-the-day entry requires a hacked-around copy of a tool called Sudocabulary:

```
wget https://raw.
githubusercontent.com/
ghalfacree/bash-scripts/master/
wordoftheday.sh
chmod +x wordoftheday.sh
./wordoftheday.sh
```

Putting it all together

Running each of these separately isn't very time-saving compared to using pen and paper, so the next trick is to add them all into a single shell script. First, download my pre-written example:

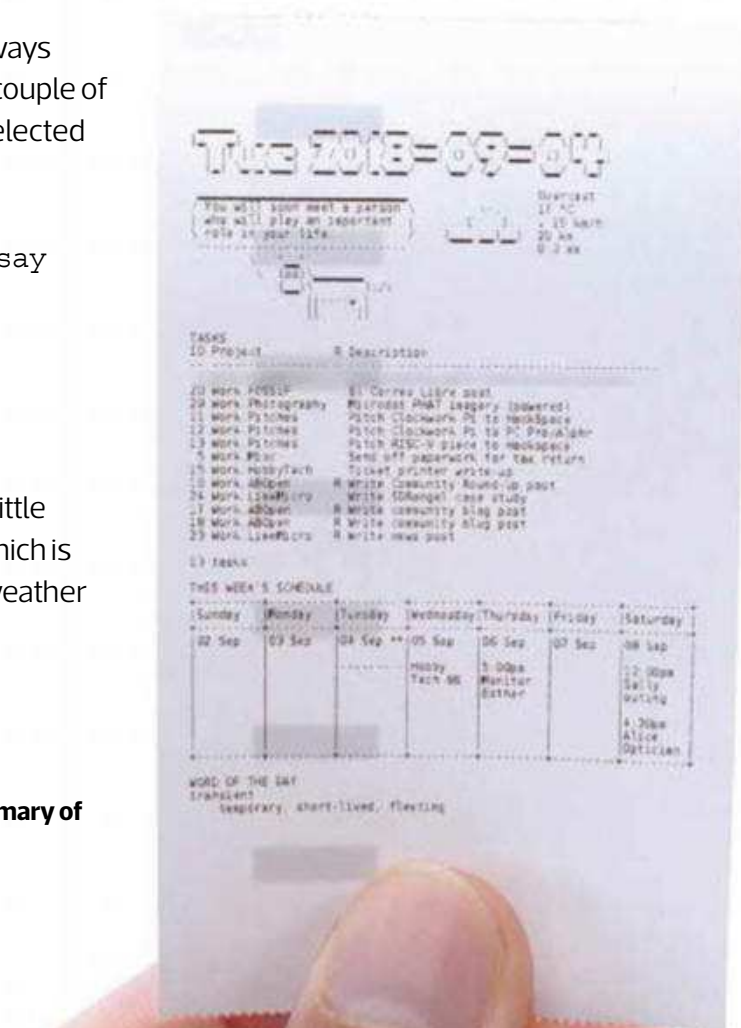
```
wget https://raw.
githubusercontent.com/
ghalfacree/bash-scripts/master/
dailyschedule.sh
chmod +x dailyschedule.sh
```

You'll need to edit the script to tweak it according to your own needs, and pay attention to the CUPS settings in the header. Also, take a look at how the program operates: the output of each program is appended to a text file, while the handy column utility is used to put the cow-based fortune and weather report on the same lines to save space. There's a few other tricks in there too, including a 'graphical' header produced by `figlet` and proper handling of TaskWarrior's exit code when no tasks are available.

Run the program to test it, and run it again with `--print` to actually print a physical report.

Finally, add it in to your crontab – using `crontab -e` – to have the report printed automatically every weekday morning at 0900:

```
0 9 * * 1-5 /home/username/
dailyschedule.sh --print
```



The finished article: a daily delivered summary of what you're supposed to be doing

REVIEW

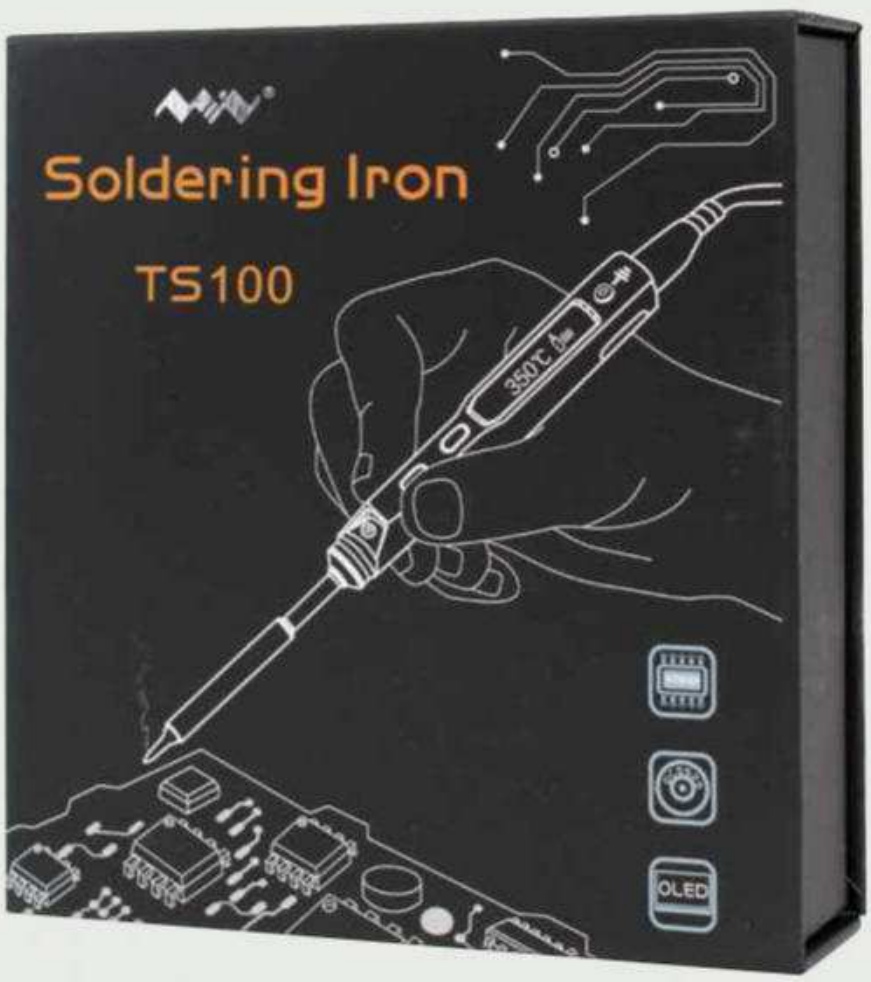
MiniWare TS100 soldering iron

You can typically two directions you can take two directions when it comes to soldering irons: a temperature-controlled iron, which comes tethered to a hefty combined control unit and power supply; or a single-temperature iron, that plugs straight into the mains with no messing. There are a few outliers, of course, such as variable-temperature irons without the tip feedback required to be temperature-controlled, which can be as simple as a standard plug-in iron with a rheostat on top. There are also highly portable gas-powered irons. By and large, however, those are your only options.

The Guangzhou e-Design Intelligent Technology TS100, more commonly found under the firm's consumer-facing MiniWare brand, is entirely different. Unboxing the iron, it's easy to assume there's a part or two missing – the body is a tiny, lightweight object not much larger than a squat pen, and there's no sign of the control base you'd expect to come with a fully temperature-controlled iron.

Bundles are available that include one or more tips for the TS-100, in a range of shapes and sizes

The TS100, you see, is self-contained, once you've slotted one of the various available tips home and tightly screwed down the retaining screw. Given a 17V-24V power supply – bundles aimed at the UK market typically come with a surprisingly compact 40W 19V supply – the TS100 boots up and, via an on-board microcontroller, sets about monitoring the temperature of the tip and keeping it within a preset range.



If the tiny box surprises you, the even tinier soldering iron inside will be a downright shock

A look at the top of the iron reveals an OLED display, along with two buttons. This area provides live feedback of the current tip temperature, whether it's over- or under-temperature, and allows you to set a desired temperature in single-degree increments. At its default 300°C setting, the iron is ready to use in a little over ten seconds, and the cooldown time once you're finished is well under a minute.

These features alone would make the TS100 an interesting device, but it has other tricks up its sleeve.

Chief among them is its programmability: a micro-USB port on the end of the iron shows up as a removable USB mass storage device with a configuration file on it. Opening this file in a text editor reveals a number of settings that can be changed, including the operating temperature, standby temperature and how long the iron can be left alone before switching from the former to the latter.

Impressively, the source code for the iron is also readily available, although MiniWare hasn't specified a licence, making it source-available rather than open-source. As a result, you can both upgrade the iron with the latest firmware and hack it to add or remove your desired features. One such hack involved a TS100 owner modifying the iron to turn it into an oscilloscope, showing a live waveform on the compact OLED display, although it lost the ability to solder until the original firmware was restored.

The TS100, then, is a blindingly clever little device. It does have its drawbacks though. The best documentation for it is in Chinese, and it's also more applicable to people

The bundled stand is functional, but not particularly special, and it can get in the way while you're soldering

Even when it's assembled, the TS100 is a compact iron – despite having its control circuitry embedded

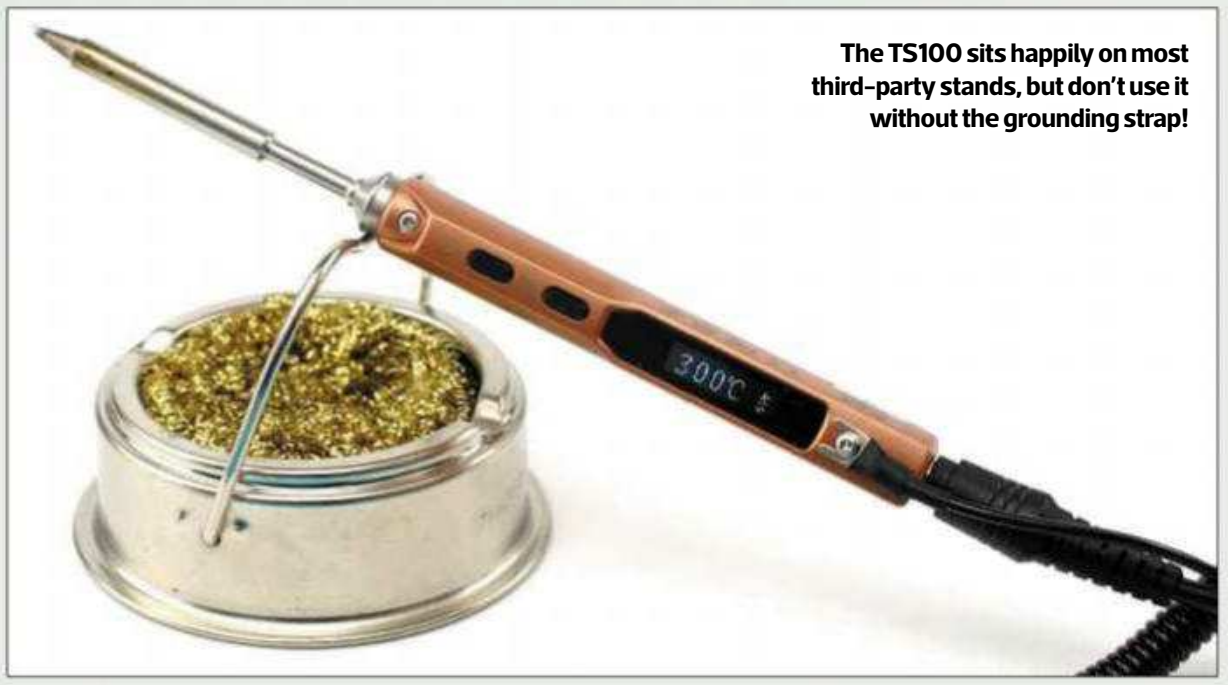
looking to hack around with the firmware than those of us wanting to do basic soldering. Also, the bundled power supply leaves the ungrounded iron tip with a floating AC voltage, easily capable of damaging sensitive electronic components. The latter can be resolved, if slightly awkwardly, by attaching a grounding strap to a screw on the top of the iron. The packaging is also of little use for storage: the box was designed for the iron, clip-on stand and packaged tips, and it doesn't fit the power supply nor the iron in assembled form.

A bigger problem is the design of the soldering iron's body itself. While sleek and slim, it lacks an iron's usual flaring to the hot end. If you're not careful, especially if you're pushing the iron tip downwards, it's possible for the iron to slip through your fingers and leave you grasping the 300°C tip shaft.

With care, though, the TS100 is a capable iron. Coupled with a lithium-polymer battery pack, you can have a portable iron not much bigger than a gas-powered iron but with considerably quicker heating, overheating protection and accurate heat control.

Admittedly, though, you can't take off the tip and use it as a heat gun – an ability that's possible with a gas iron.

MiniWare has recently released the TS80, a variant with a USB Type-C connection that's compatible with Quick Charge mains and battery chargers, but its price makes the TS100 a safer bet for folks who don't need the increased portability. The TS100, as reviewed, is available from UK resellers on **www.amazon.co.uk** for £60 (inc VAT) with one tip, grounding strap and power supply included. The TS80, on the other hand, has yet to arrive in the UK, and has a price north of £80 (inc VAT) without a power supply via Amazon dropshippers. Both models are also available to import from China for a reduced price via sites, including **www.aliexpress.com**, but if you choose this route, you'll need to watch out for import VAT when it lands.



The TS100 sits happily on most third-party stands, but don't use it without the grounding strap!

NEWS IN BRIEF

Checkmate A1500 reborn as PC, Amiga and Raspberry Pi case

The Checkmate A1500, a third-party upgrade kit to turn the Amiga A500 into a desktop machine with increased expansion capabilities, is now being remade as a universal chassis that can house original Amiga, modern PC or Raspberry Pi hardware. Dubbed the Checkmate A1500 Plus, and created by the A1500's original creator Stephen Jones, the new design takes inspiration from the Commodore A3000 and is to be made available in modern black and classic beige finishes.

Internally, the case accepts micro-ATX and mini-ITX motherboards, as well as Amiga A500, A600, and A1200 motherboards, plus Raspberry Pis, and a handful of Amiga-compatible motherboards. Pricing is set at £159 inc VAT plus shipping, with more information available at **http://amigasystems.com**

REVIEW

Exapunks

Regular readers may recall my love for Zachtronics' programming-themed games.

From the vintage computing simulator TIS-100 (see Issue 156, p100) to the mind-bending hardware-hacking Shenzhen I/O (see Issue 161, p100), Zachtronics' puzzle games get cleverer and cleverer.

The latest game, Exapunks, is no exception. Where TIS-100 drew its inspiration from vintage minicomputing and Shenzhen I/O from Chinese hardware firms, Exapunks takes late-1980s/early-1990s cyberpunk as its theme. The player is cast in the role of a semi-retired hacker, now suffering from the phage – an illness that sees organic body parts slowly replaced by non-functioning computer hardware – and yes, that can involve hacking your own body to stay alive.

The plot is deeper than previous games, revolving around finding ways to earn money for the medicine that fights off the phage, as well as discussions on the meaning of life and morality with what appears to be a sentient artificial intelligence. There are more than a few pop-culture references too: one early mission sees you going head-to-head with another hacker to take control of a TV network, echoing a scene in Iain Softley's classic Hackers, while another mission uses a real-world instance of bypassing region protection in games consoles so you can unlock an in-game games console and play a tricky match-three game.

If you've ever wanted to hack the planet while coding in a very basic assembly language, Exapunks is for you

As always with Zachtronics games, the 'feelies' are top-notch and really immerse you in the game world

There's also a solitaire-style card game that needs to be stolen from a foreign network and a Game Boy-like handheld for which you're encouraged to write you own games – once you've figured out how to hack your way past the firmware lock and into development mode, anyway. These games can even be in 3D, if you have a pair of red-green anaglyph glasses handy.

As before, much of the game's lore is hidden in 'feelies', game-world documentation bundled with the game as PDFs in the form of cyberpunk 'zine Trash World News. A limited production run of physical feelies had printed copies, along with anaglyph glasses and a Secret Envelope only to be opened when the game is complete – although stocks have now, sadly, run out.

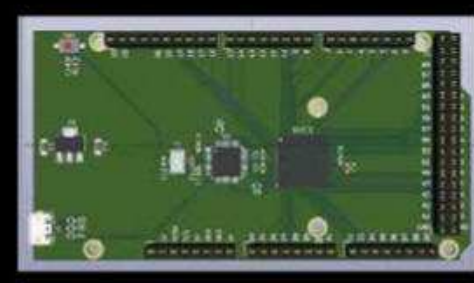
The gameplay itself will be immediately familiar to Zachtronics fans: the player has to solve a puzzle by writing assembly code based on a fictional, and very limited, instruction set. The twist is that the programs run on Execution Agents, or EXAs, which can run around the playing area, pick up files, drop files and even try to kill other EXAs.

When you've solved the puzzle, your solution is ranked on three metrics: the number of lines of code it required, the number of processor cycles it took and the activity of the EXAs. These metrics are then graphed on the main screen, both against global players and your friends. This time, there's true multiplayer too – 'hacker battle' missions, such as the TV network takeover one, allow you to pit your solution against your friends' solutions, adding an extra competitive element to the mix.

If TIS-100 and Shenzhen I/O sent you to sleep, or the idea of writing low-level programs for fun doesn't appeal, Exapunks isn't for you. For the curious, though, you'll find hours of brain-tingling and occasionally hair-pulling puzzle action. Exapunks is available now for £15.49 inc VAT from Steam. CPC

NEWS IN BRIEF

Retro-uC board to switch between vintage CPUs



A startup dubbed Chips4Makers has launched a crowdfunding campaign to launch a development board with a difference: it's based on a field-programmable gate array (FPGA), and it can switch between vintage processor cores. The Retro-uC 'retro microcontroller' shares a footprint with the Arduino Mega, but its FPGA core can switch into Zilog Z80, MOS 6502 and Motorola M68K modes, popularised by the ZX Spectrum, Commodore 64, and Commodore Amiga respectively. The source code and tool chain, meanwhile, will be released under an open-source licence. More information is available from **www.crowdsupply.com/chips4makers**

Gareth Halfacree is the news reporter at www.bit-tech.net, and a keen computer hobbyist who likes to tinker with technology. @ghalfacree

WIN! A be quiet! Silent Base 801 Window case

Silent Base 801

Introducing the next PC case in the be quiet! Silent Base series, the Silent Base 801 offers excellent usability and silent operation. The relocatable motherboard tray and PSU shroud satisfy the highest requirements for a neat and individual interior.

Meanwhile, smart cable management and various new features, such as a detachable top bracket for radiator installation, underline this case's usability. The Silent Base 801 is available in two versions, with or without a tinted and tempered glass window, with each version available in a choice of three colour accents: black, orange and silver. The competition winner will be able to choose their preferred colour, subject to availability.

HIGHLIGHTS OF THE SILENT BASE 801

- Noise dampening vents provide excellent air permeability with maximum noise reduction
- Extra-thick 10mm insulation mats
- Three preinstalled Pure Wings 2 140mm fans for silent airflow
- Side panels can be detached with push pins
- PSU shroud and smart hard drive slot covers provide a neat interior
- Decoupled motherboard tray can be relocated for an inverted layout
- Full metal body provides stability and elegant feel
- Ready for radiators up to 420mm in size
- Side panel made of tinted and tempered glass

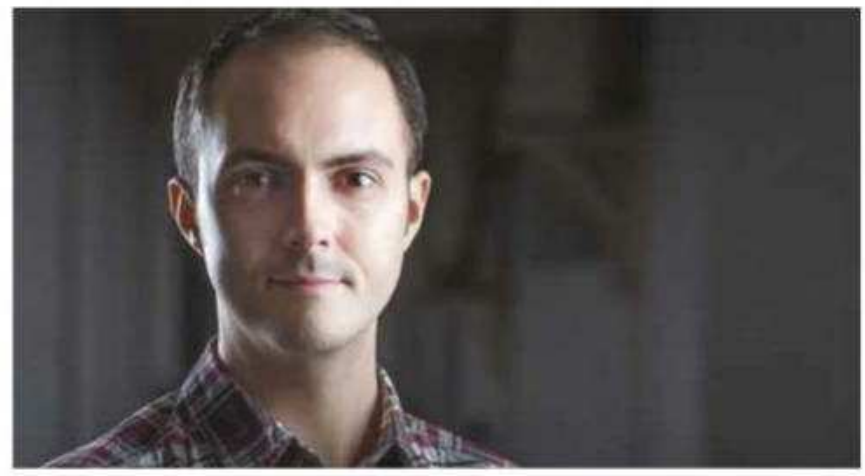
bequietenglish **bequietofficial**

To be in with a chance of winning one of these fantastic cases, simply answer the question below:

QUESTION: Which of these answers is *not* a colour option for the Silent Base 801
A. Silver **B.** Green **C.** Black **D.** Orange

be quiet!®

Email your answer to competition@custompcmag.org.uk, with 'be quiet! Competition 183' in the Subject line.
Closing date 15 November, 2018. See **www.dennis.co.uk/comp/terms** for the full competition rules.



ANTONY LEATHER'S

Customised PC

Case mods, tools, techniques, water-cooling gear and everything to do with PC modding

Water-cooling AMD's Threadripper 2990WX

Whether you view AMD's 32-core Threadripper as a triumph over Intel, or a disappointment due to the fact that it's not as good an all-rounder as the 16-core Threadripper chips (or Intel's Core i9-7980XE for that matter), it can be a monster record-breaker. This mighty CPU can tear through multi-threaded benchmarks, and it will make short work of workstation 3D modelling workloads too.

However, with 32 cores packed under that heatspreader, you end up with a massive 250W TDP, requiring some serious cooling. AMD has mentioned to me on several occasions that it expects most Threadripper 2990WX users will need to opt for some form of liquid cooling. On the plus side, the CPU has a soldered heatspreader, rather than using thermal paste between the dies and the heatspreader, so we should see reasonable scaling when using hefty cooling setups.

This month I decided to investigate whether it's worth splashing out on a custom water-cooling system for the 2990WX, or if a standard all-in-one liquid cooler designed for Threadripper CPUs would suffice. To start, the all-in-one liquid (AIO) cooler of choice is the Enermax LiqTech TR4 240, which sports a 40mm-thick radiator and two

Enermax's LiqTech TR4 240 has a large contact plate that completely encompasses the huge Threadripper heatspreader

powerful 2,300rpm fans, along with a pump that can reach up to 3,000rpm with its impellor. It also has a large contact plate that completely encompasses the huge Threadripper heatspreader. The downside is that it costs £140 inc VAT, so it's hardly a low budget option – a custom, CPU-only water-cooling loop won't be massively more expensive.

Meanwhile, the water-cooling components I tested for comparison included a Bitspower ASRX399MTC waterblock, which not only cools the CPU, but also the VRMs on the ASRock X399M Taichi motherboard I used, potentially impacting on performance with AMD's various boosting modes. I also used a Laing DDC pump and a 360mm radiator with a trio of 1,800rpm fans. These fans dish out less airflow than the spinners on the Enermax cooler, but they're considerably quieter and there are three of them. It will be interesting to see if custom water cooling with this setup can offer the same or better temperatures than the AIO liquid cooler at much lower noise levels.

I ran several tests to gather results. Firstly, I stress-tested each cooling arrangement with Precision Boost Overdrive (PBO) enabled, which adds power headroom and can allow the CPU to reach higher single and all-core frequencies. I ran the same test with all the CPU cores overclocked to 4.1GHz as well, with a vcore of 1.375V, recording the temperature at both settings on both coolers. Finally, I ran Cinebench's multi-core test to get a score at each setting on both coolers, so the results will hopefully show whether or not custom water cooling offers better temperatures and improved performance.

The first test was Cinebench at stock speed, and both coolers returned scores in the mid-4,800s, where any difference was within the margin of

Bitspower's ASRX399MTC waterblock not only cools the CPU, but also the VRMs on ASRock's X399M Taichi motherboard

error – custom water cooling offers little or no benefit at stock speed. Applying PBO and adding 50 per cent to the power limits available saw these scores rise to the mid-5,800s, with results again within the margin of error. Clearly, there's little impact of any extra cooling here, given that the results were practically identical, with around 1,000 points being added by switching on PBO. However, the CPU ran 4°C cooler with the custom water-cooled system in the stress test at these settings, which lasted for ten minutes, despite the fact that its fans were running 500rpm slower than the ones on the AIO cooler.

Manually overclocking the Threadripper 2990WX has been a little tricky, with the chip hitting some stability issues as you reach its limits, and we were disappointed to find that the custom water-cooling loop couldn't get us further than the all-core 4.1GHz frequency we managed with the all-in-one liquid cooler.

This clock speed was achieved with a 1.375V vcore, but any higher settings resulted in temperatures continuing to climb well above 90°C after a few minutes, or the system switching off, during a heavily multi-threaded stress test.

We also tried switching to the monstrous MSI MEG X399 Creation motherboard (see Issue 182, p30) to see if we could overclock our chip further, but were met with identical results. Again, the custom water-cooling system offered a better ratio of cooling to noise, managing a 1°C lower CPU temperature with much quieter fans, but the all-core overclock still pushed temperatures close to 90°C. The custom water-cooling system also managed to add a few hundred points to the score with this setup, though, which could be a result of the MSI board's additional VRM cooling. In terms of noise, I measured a noisy 60dBA from the all-in-one liquid cooler, but a much more reasonable 52dBA from the custom water-cooling system, with both sets of fans running at maximum speed.

Ultimately, the results point at a capable all-in-one liquid cooler being able to deal with the heat of an overclocked Threadripper 2990WX, and for less money than a custom water-cooling setup too, but at the cost of noise. The Enermax LiqTech TR4 240 was incredibly loud at full speed – you certainly wouldn't want to sit next to it while your PC churns through a 3D modelling workload over the course of half an hour. It's also true that, with slower fans, which many other AIO liquid coolers include, it's likely our overclock would end up being out of the range of most 240mm liquid coolers, requiring a step up to a larger 280mm or 360mm radiator – the Enermax's 240mm radiator became very hot during these tests.

Even so, I was a little disappointed to find that the only real benefit of using custom water cooling on a Threadripper 2990WX seemed to be lower noise levels. We couldn't push our CPU any further – of course, other samples may be able to overclock higher, but you'd still be dealing with extremely toasty temperatures. Custom water cooling offered benefits at stock speed with PBO enabled, but once overclocked, apart from a small performance boost and lower noise, there wasn't much difference between the two setups, even with the custom loop having a much larger radiator and more powerful pump.

That said, if I had the cash to throw at a PC with a £1,700 CPU, spending another £70 or so to get a quieter PC for those lengthy multi-threaded workloads would be a no-brainer. Plus, there are nearly as many Socket TR4 waterblocks available now as TR4-compatible all-in-one liquid coolers, especially if you want your block to cover the entire heatspreader. CPC

Our custom water-cooling loop didn't give us more overclocking headroom than the AIO liquid cooler we also tested, but it was quieter

Antony Leather is Custom PC's modding editor @antonyleather

How to Control fans and pumps

Antony Leather shows you how to automatically control your pumps and fans with your motherboard

TOTAL PROJECT TIME / 1 HOUR

Motherboard fan control systems have evolved in leaps and bounds in recent years. In fact, there's now little point opting for a separate fan controller, as your motherboard can not only control 3-pin and 4-pin fans, but also water-cooling pumps. All the main four motherboard manufacturers now provide both EFI and Windows-based suites that allow you to set up permanent profiles.

You can control each individual fan, switching them off at lower temperatures to cut noise, and the more advanced suites also allow you to choose from a range of temperature inputs, such as the VRMs or M.2 slots, to dictate fan speed. In this guide, we'll look at how to connect your fans and pumps to your motherboard and the various ways to control them automatically.

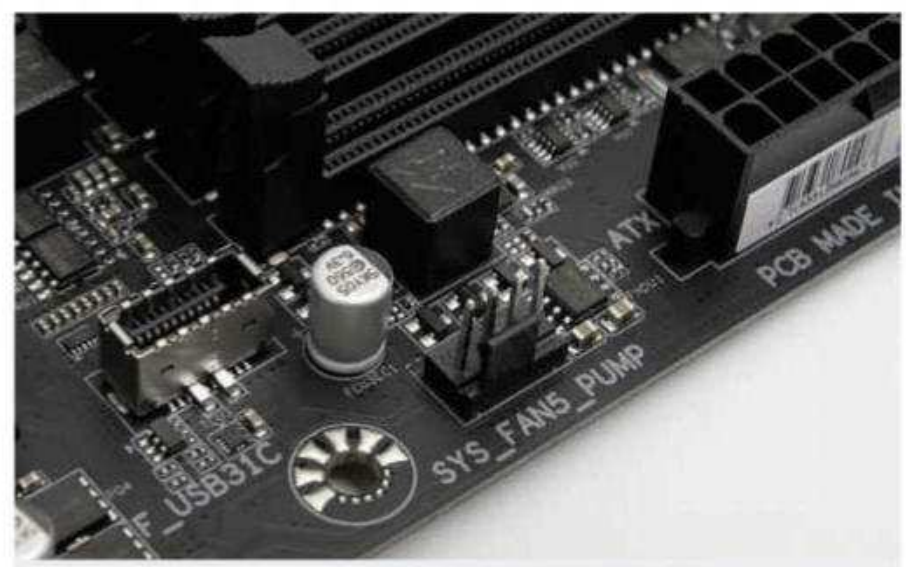
TOOLS YOU'LL NEED

3-pin female to 4-pin male Molex adaptor /
www.ebay.co.uk

PWM-controlled pump /
www.overclockers.co.uk

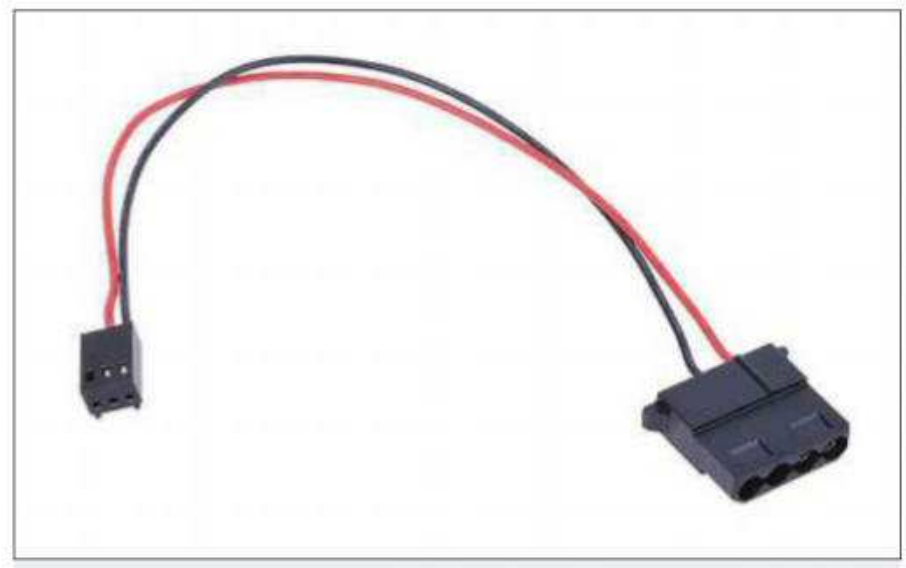
1 / CHECK POWER LIMITS

Most enthusiast motherboards can power water-cooling pumps, but the headers' power limits may restrict the speed. Asus and Gigabyte boards usually have at least one header that offers up to 3A or 36W, while MSI boards are limited to 2A or 24W.



2 / IDENTIFY HEADERS

Connect your AIO liquid cooler to your motherboard's pump header if there is one. The motherboard will then identify it as a pump and avoid applying lower voltages that could see it stop working under low loads.

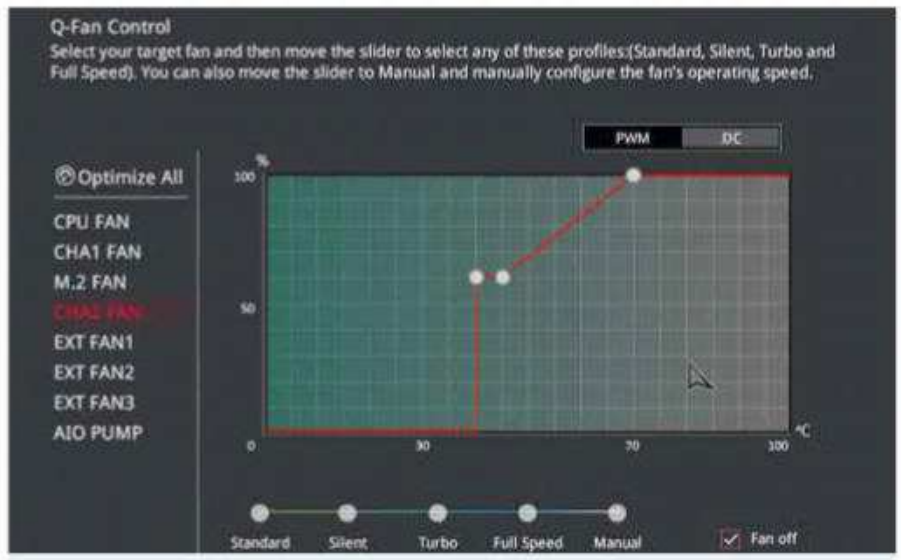


3 / USE AN ADAPTOR

If your DIY water-cooling pump lacks a PWM input or 3-pin power cable, your motherboard can still control it. Using a 3-pin to 4-pin male Molex adaptor, you can power your pump from a standard 3-pin header as long as it provides enough power.

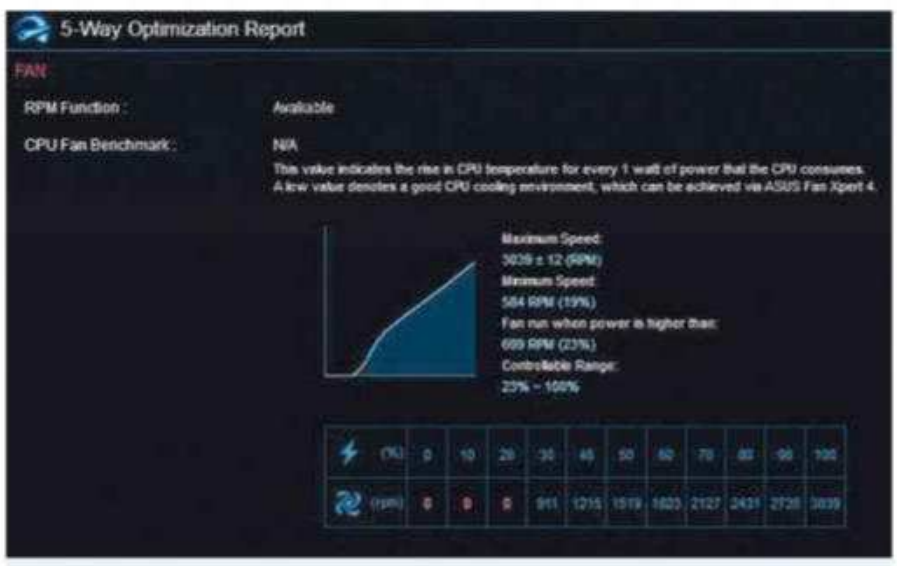
4 / USE PWM WITH YOUR PUMP

Many new Laing-based pumps include a PWM cable as well as a Molex cable, allowing your motherboard to set the speed of the pump's impellor. You don't need to worry about power limits here; any 4-pin header will be able to control it.



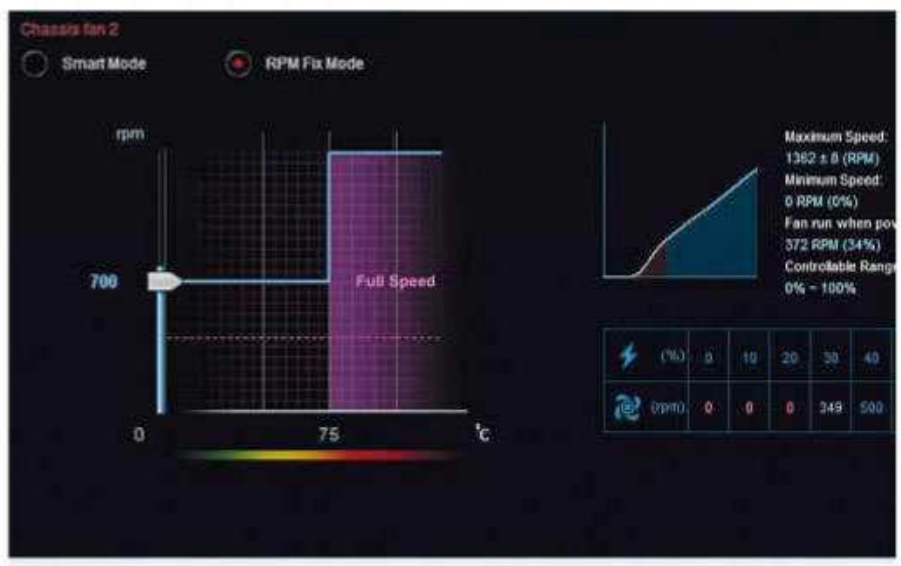
5 / PWM VS CONSTANT VOLTAGE

Fans with 3-pin plugs will receive a constant voltage, but 4-pin fans can be controlled with pulse width modulation (PWM), which applies blips of 12V power to make fans spin, reducing electronic noise and allowing fans to spin at much lower speeds.



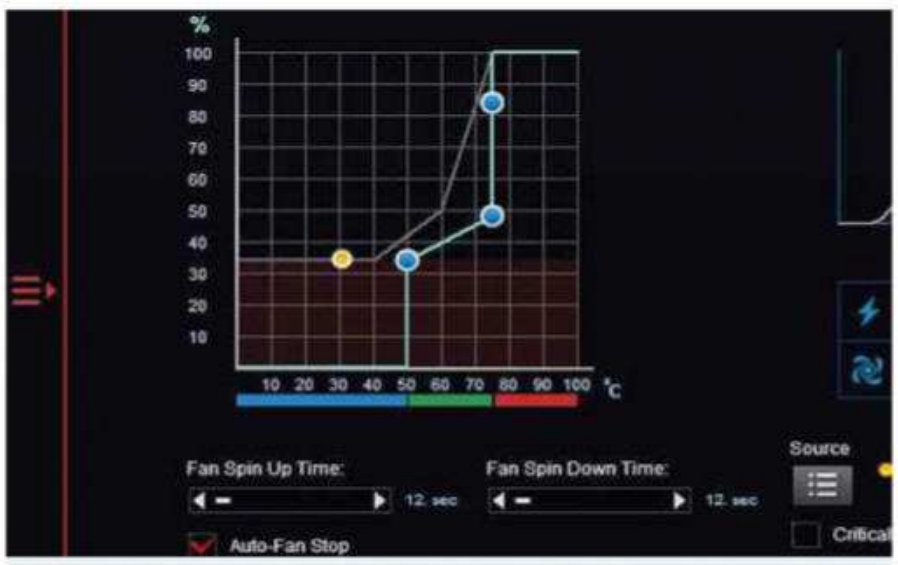
6 / FAN TUNING

Detailed fan tuning can usually be performed in the EFI and Windows. Your motherboard tests each fan's voltage and speed range, and applies these limits to its automatic control system, so you can take advantage of the entire speed range.



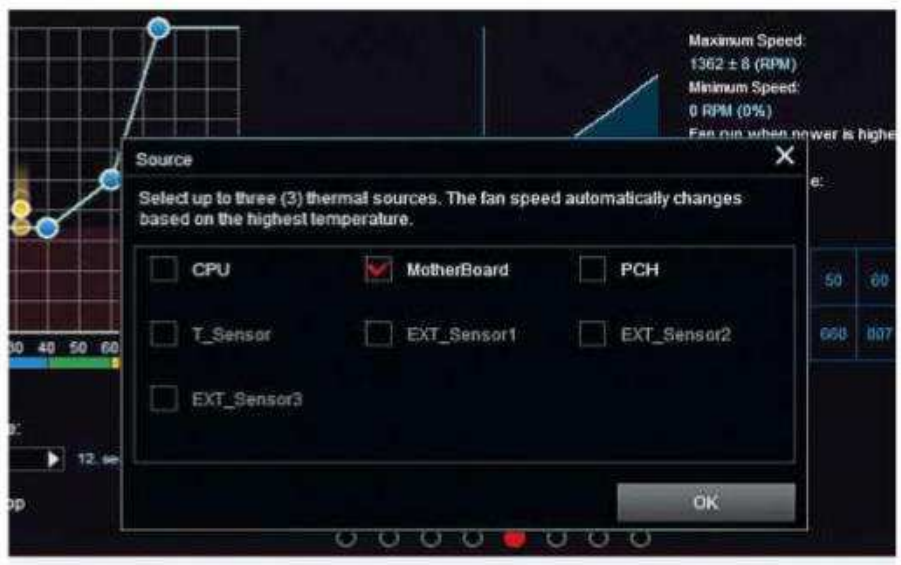
7 / FIXED RPM

You can usually set your fan to spin at a constant speed in your motherboard's software or EFI too. You can cut noise by limiting additional case fan speeds, hitting the best airflow-to-noise ratio, or simply set all your fans to spin at inaudible speeds.



8 / CUSTOM RESPONSE CURVE

The custom fan speed curve is the most useful modern fan control feature. It allows you to set specific speeds for certain temperatures, increasing fan speeds as more heat is produced. Some software can also switch off fans below certain temperatures.



9 / TEMPERATURE INPUT

If don't want to use the CPU temperature as the fan control input, many software and EFI control suites allow you to change the input. It could be the chipset, VRMs, an external thermal probe in the case, or even a water-cooling coolant probe. CPC

How to
Fit motherboard monoblocks

Antony Leather shows you how to water-cool your CPU and motherboard hotspots in one go with a monoblock

TOTAL PROJECT TIME / 2 HOURS

Whether you're looking for more overclocking headroom, quieter operation or simply a great-looking PC, there are many benefits to water-cooling your PC, and using a motherboard monoblock kills several birds with one stone.

These large waterblocks aren't just great for aesthetic bonus points – they're also usually much easier to fit than several separate blocks. They have just one inlet and outlet, yet they cool several hotspots in one go, including your CPU. The benefits are that both your motherboard and CPU can be water-cooled by a single waterblock, saving time and money, while also adding a huge slab of water-cooling chic to your motherboard.

TOOLS YOU'LL NEED

Motherboard monoblock /
www.overclockers.co.uk

Thermal paste /
www.overclockers.co.uk

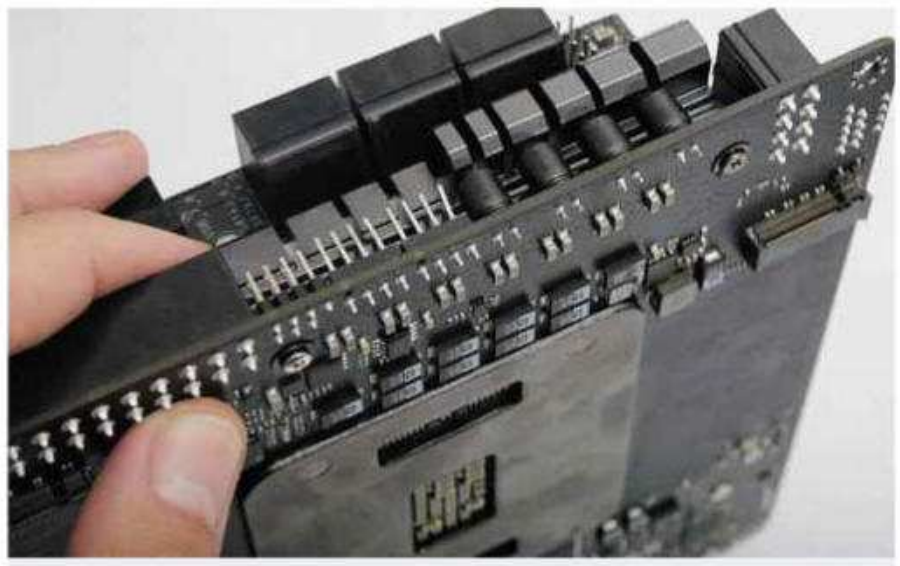
Micro screwdriver /
Most hardware stores

1 / FIND COMPATIBLE MONOBLOCK

Not all motherboards have compatible monoblocks, but manufacturers EKWB and Bitspower are your best bets when it comes to obtaining a full-cover monoblock for your motherboard. Head over to their websites to see if you can find one.

2 / PLAN TUBING ROUTES

The inlet and outlet on monoblocks can be in very different locations to the ones on dedicated waterblocks, so check the route your tubing will need to follow and that you have enough tubing, especially if you're replacing an existing waterblock.

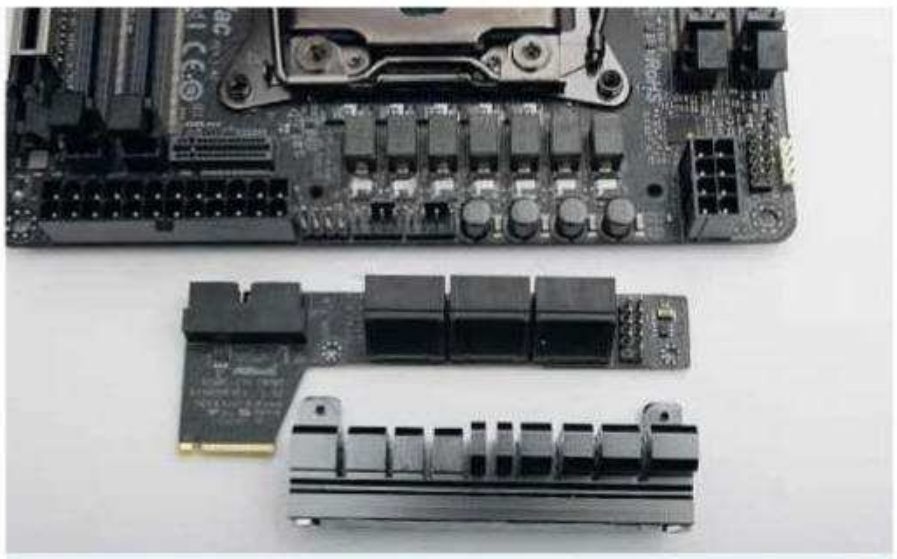


3 / FIND HEATSINK MOUNTING POINTS

Before you install the monoblock, locate the various mounting points for the VRM heatsinks on the reverse of the PCB. You may find that other fittings need to be removed, as well as the heatsinks, before you can install it.

4 / USE CONTAINER FOR SCREWS

For warranty purposes, and if you want to sell the motherboard at a later date, always place redundant screws in a container and then ideally in your motherboard box. Don't leave them loose, as they're extremely small.



5 / REMOVE HEATSINKS

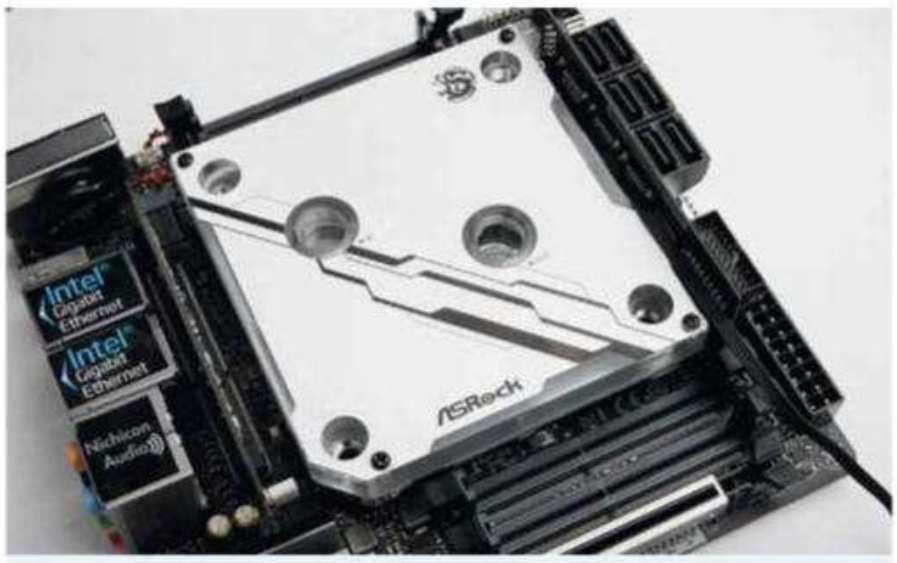
Unscrew the heatsinks and remove them. If they don't budge, use a hairdryer at its maximum setting on the area for 30 seconds, from a few inches away, to loosen the thermal pads. Bear in mind that this action may well void your warranty, however.

6 / KEEP THERMAL PADS

Collect all the thermal pad material and place it onto the heatsink, so you can replace it again at a later date if you want to sell or return the motherboard. It's fine if they rip, and you can always purchase replacements if necessary.

7 / CLEAN VRMS AND CPU

Use TIM cleaner or isopropyl alcohol to clean your CPU and VRMs before you apply any new paste or pads. Use a microfibre cloth, rather than tissue, as the latter can leave small particles behind.



8 / TEST-FIT MONOBLOCK

Before you apply the paste and pads, test-fit the monoblock, so you can get a feel for how to put it in place. This preliminary step will help to avoid damaging the thermal pads and spreading paste everywhere if you get it wrong.

9 / APPLY THERMAL PASTE

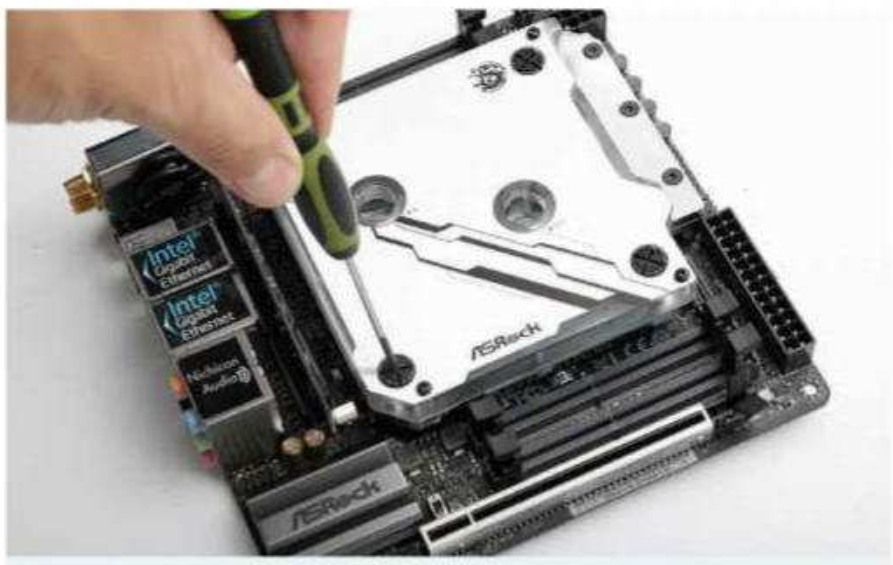
Apply thermal paste in a cross shape in thin lines. These lines should then spread to cover the whole area when the block is fitted to the motherboard. Use thermal paste that isn't electrically conductive, especially if you need to apply it on the VRMs.

10 / APPLY NEW THERMAL PADS

Thermal pads are usually included with the monoblock and often need to be trimmed to size. Follow the instructions carefully, using the correct thickness; sometimes several different pad sizes are used on different parts of the block.

11 / FLUSH WATERBLOCK

Run water through the block to clear any residue from the manufacturing process. If the O-rings inside are visible, check there are no gaps in the seals. Don't worry if you can't see them; a simple leak test will prevent disasters once your loop is built.



12 / INSTALL MONOBLOCK

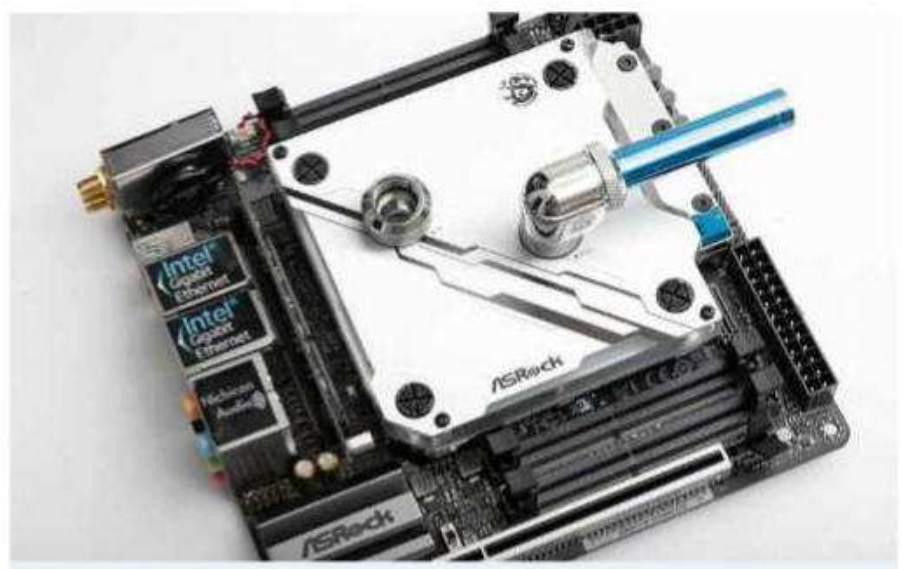
With the paste and pads applied, go ahead and install the monoblock. Use all the fittings and screws required for installation and tighten them gradually in opposite corners to ensure a level mount.

13 / REMOVE AND CHECK CONTACT

As monoblocks are much larger than individual waterblocks, it's important to check the contact with the CPU. Remove the block once you've installed it and inspect the spread of thermal paste. It should be even, as shown in our photo.

14 / CONNECT RGB LIGHTING

Many monoblocks include RGB lighting that can illuminate the acrylic or manufacturer logos. Identify whether the connector is a 3-pin addressable or standard 4-pin type, then locate the correct header on your motherboard.



15 / INSTALL FITTINGS

Finally, install your compression fittings before mounting the motherboard in the case. This step will make it easier to check the fittings are seated properly, and you'll be able to properly support the block while you tighten them too. CPC

ANTONY LEATHER'S

TOP TOOLS

THE DRILL

It's easy to think of the drill as a rather clunky, single-purpose device, when in fact it can be useful for a variety of tasks. Attachments allow it to act as a polisher, a cutter of fan or radiator blowholes, and it's also useful for drilling out rivets in PC cases. It can do a lot more than just drill small holes, and in my mind it's the most essential tool in any PC modder's toolkit.

Cordless drills usually lack torque compared with their mains-powered counterparts

Corded vs cordless

I have to admit that I think cordless tools are overrated. They usually lack torque compared with their mains-powered counterparts and this limitation, combined with the fact that even expensive batteries don't last long under heavy loads, means a corded mains-powered drill is usually the best option when dealing with steel and aluminium. You can then drill away for hours, never needing to worry about your battery dying. I've experienced enough cordless drills using up all their batteries while cutting blowholes in steel cases to put make me firmly a corded drill man now.

The step drill

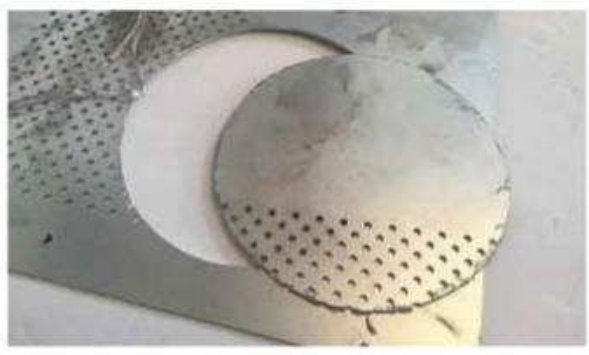
Changing drill bits can be a pain, but it's often essential, especially when creating pilot holes for larger drills. A step drill is a brilliant addition to your drill's carry case, as it not only means you don't have to swap drill bits as often, but it can make drilling large holes much easier too. In fact, a couple of step drills can potentially replace an entire box of individual drill bits.

It attaches to your drill just like a normal drill bit, but its cone shape has several drill widths or steps cut into it. The further you drill in to an object, the wider it cuts the hole, gradually increasing the width in easy-to-manage steps. The downside, of course, is that step drills only work with relatively flat objects, and you'll also need plenty of clearance behind the surface if you want to make use of the larger steps.

There are several varieties of step drills and the cheaper ones usually cover the 4-30mm range in 2mm steps. Thankfully, you can also buy step drills that cover smaller ranges on a per-millimetre scale, as well as odd numbers, and there are some very good-value step drill sets available, covering ranges from 3mm up to 40mm, so (depending on your needs) you really can replace sets of dozens of drill bits with just a few step drills. They're also much more durable and less likely to break.

The holesaw

As you move beyond hole widths of 30mm, it becomes necessary to use a holesaw, simply because drill bits become cumbersome and inaccurate as you start drilling out vast amounts of metal. A holesaw gets around this problem, literally, by just cutting a ring in the material with which you're working. You'll then be left with a solid metal disc and a neat hole. The sawing rings attach to a bit that secures to your drill, and the latter usually has its own pilot drill that provides an anchor to prevent the saw from moving.



Polishing bits

If you want to buff up your new paint job or remove scratches from an acrylic panel using a polishing compound, polishing pads can turn your drill into a high-power polisher, saving on elbow grease. They usually come in sets with soft mitts and aggressive sponges, which can tackle a range of tasks. The pads attach to a base using Velcro and then a screw-in bit secures to the base, allowing your drill to take hold. They're useful for other tasks too, such as sprucing up old car headlight lenses. CPC

Readers' Drives

Goon Squad

Ethan Cooper's Rage 2-inspired mod packs a ridiculous amount of hardware into a micro-ATX case, while sporting some colourful graffiti and genuine scorch marks

/MEET THY MAKER

Name Ethan Cooper

Age 23

Location Geelong, Australia

Occupation QA analyst

Main uses for PC Display at events

Likes Hunting, electronics, Batman, Spartan Races, good whiskey, impressions

Dislikes Being idle, negativity, puns

CPC: What was the original inspiration behind Goon Squad?

Ethan: My build is based on the upcoming game Rage 2. My main inspiration came from the Goon Squad tank shown in the game. With its industrial design and vibrant colours, it has a great artistic style. I'm a stickler for detail and I spent hours going over E3 footage to make sure I captured all the nuances of the tank design.

The Goon Squad is a group of bandits in Rage 2 that cover their vehicles, and themselves, in graffiti and paint. I chose to use their vehicles as a base for the build to push myself out of my comfort zone, as I don't generally use more than two or three colours per build, but the total number of colours in this build exceeded the better part of 20.

CPC: Why did you use the Cooler Master Q300P case?

Ethan: To add some challenge to the build – I wanted to cram as much hardware and power into a micro-ATX case as possible. I'd also never worked with this case before. Each case brings its own challenges, so I enjoy mixing it up!

CPC: What specs did you choose?

Ethan: This build is my main entry into the Cooler Master World Series 2018. I wanted to bring a project together that shows off my unique creative style while also demonstrating my technical side with the hardware. As I was using a micro-ATX case, I deliberately selected hardware that wouldn't usually be considered in this size of case. It added a new level of difficulty, as I had to have millimetre-level accuracy when putting it all together. I was also in a very fortunate position with all the hardware being sponsored by various companies.

CPC: What difficulties did you come across?

Ethan: The hardest part of this project by far was cramming all of the hardware in the case. I had to mod the case quite extensively to make all the hardware fit. I had to make new GPU brackets and PSU brackets, and I rotated the case to make it look more balanced. There ended up being just a 3mm gap between the GPUs and PSU.

The most time-consuming aspect of the build was assembly. With the challenge of limited space, I had to be meticulous with the order the hardware went into the case. I learned very quickly when I found out that one piece of hardware would block the installation of another. This situation caused me to reassess my process as I went along. Another challenge, which I'd never experienced before, was the balance of colour. Since so many colours were used in the graffiti, I had to ensure that certain colours didn't overpower others.

CPC: How did you create the rusted metal finish?

Ethan: I started by making the whole case look like new metal by painting it in a metallic charcoal colour. Once it had dried, I added layers of yellow, red, black and various browns using a dabbing technique. These paints were applied on all surfaces, then I removed the excess by dabbing with a clean dry rag.

The pitted metal effect on the plastic sections of the case was created by strategically burning the case with a gas torch. Super-heating the plastic creates a bubble effect, and the heat could cause the plastic to potentially warp and bend, so I clamped the pieces to the bench during the process to ensure they would remain as flat as possible. Black and dark brown washes were applied all over the case, with a particular focus on the bubbles caused by fire to create the illusion of more depth.

CPC: What tools and machinery did you use?

Ethan: As with all my builds, I used a variety of tools to complete the build. The most noteworthy is my trusty Dremel Rotary tool.

I *love* my Dremel. I used it to cut the unneeded plastic and metal to make space for all the hardware, and to make the new brackets.

At this point, my Dremel is more of an extension of my arm, as it's my go-to-tool for the majority of my builds.

Rustic old builds are my favourite, as I have a lot more creative freedom. On this one, I got to use a variety of paints and my favourite modding tool of all – FIRE! It allowed me to create more depth in the piece, as well as adding general scorch marks, which fit perfectly with the theme.

FOR MORE INFO
www.technologyandgaming.com.au

CPC: How long did the build process take?

Ethan: From start to finish, the build took me around a week. I generally tend to keep my deadlines tight, as I want to prevent any procrastination. From experience, I've learned that the crunch and working under stress prevents me from overthinking designs, as well as getting lost in prototypes and variants of the build.

CPC: What did you learn from this build?

Ethan: To be truly honest, this build didn't push my skills too hard. Working with the smaller space and adapting my creative style was certainly a learning experience, and I gained a further understanding of balancing colours, but I remained pretty much in my comfort zone in a technical sense.

However, I now know why few people try to jam ATX hardware into a micro-ATX case. Making the case size work with all that hardware was a big, and time-consuming, learning curve.

CPC: Are you happy with the end result, and is there anything you'd do differently if you built it again?

Ethan: I go through the same process with all of my builds. I get the idea in my head and get to work, but when I get around halfway, when it looks like some parts don't match, I always think: 'What have I done?!' However, I've come to learn to completely ignore that little voice, remain confident and continue with my design. As of yet, this attitude hasn't failed me, and I'm always happy with my builds once they're finished.

Given the chaotic nature of this case mod, I think if I were to do it again, it would turn out differently, as most of the graffiti wasn't planned, and neither was the weathering. It was all slapped onto places where I thought it would look good at the time.

Specifically, though, I think I would have flipped the hardware arrangement around and put the motherboard on top, strategically placing the pumps out of the way so that the I/O panel could be accessed more easily.

If I'd built this PC for personal use, I would also have created a base to lift the PC, allowing the inputs to be more easily accessed. However, these details aren't overly important for a PC built to be displayed at events. 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.

SYSTEM SPECS

CPU Intel Core i7-8700K

Graphics 2 x Gigabyte Aorus GeForce GTX 1080 Ti WaterForce Xtreme

Case Cooler Master Q300P

Memory 32GB Team Group Delta RGB DDR4

Motherboard Gigabyte Aorus Z370 Gaming 7

Storage 1TB Samsung 960 Pro, 512GB Samsung 960 Pro, 1TB Samsung 960 Evo

PSU Cooler Master V850

Cooling 2 x Cooler Master MasterLiquid 240, EK fittings and tubing

Win all these prizes!

We've teamed up with some of the world's leading PC manufacturers and retailers to offer this great range of prizes to each lucky Readers' Drives winner. If your creation is featured in the magazine then you'll walk away with all of the prizes listed on this page, so get in your entries!

Corsair K70 LUX RGB keyboard with your choice of switches

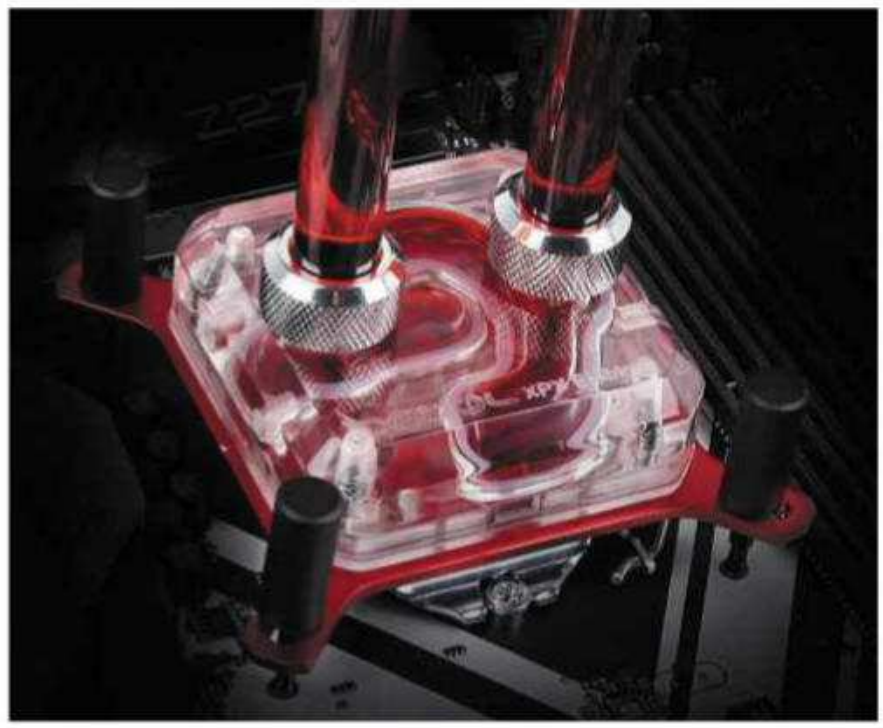
TOTAL VALUE £160 inc VAT / **MANUFACTURER** www.corsair.com

The K70 LUX RGB is a part of Corsair's LUX flagship line of gaming keyboards, featuring Cherry MX key switches backed by a lightweight, durable aluminium frame and dynamic, multi-coloured lighting. The USB pass-through port is positioned for uninterrupted gameplay, and ready for your mouse or wireless headset adaptor. You can also harness the power of CUE for sophisticated macro programming and dramatic lighting effects and animations.

Meanwhile, 100 per cent anti-ghosting with full key rollover on USB helps to ensure accuracy, so every keystroke translates directly into accurate gameplay. The contoured, textured FPS and MOBA keycap sets keep you in control, while the Cherry MX key switches give you a linear response and fast actuation. Corsair will provide a keyboard with your own choice of Cherry MX switches – both Brown and Red RGB models are available.

Alphacool water-cooling gear

VALUE £150 inc VAT / **MANUFACTURER** www.alphacool.com, www.aqua-tuning.co.uk



Water-cooling hardware manufacturer Alphacool is offering a choice of £150-worth of its water-cooling components to every featured Readers' Drives modder. The company is behind some great products we've seen recently, including all-in-one liquid coolers and external radiators. For your prize, you can select from DIY water-cooling kits, the Eiswolf and Eisbaer all-in-one CPU and GPU liquid coolers, as well as a vast range of individual components, including waterblocks (pictured), fittings, reservoirs, pumps and radiators. Alphacool also makes coolant, tubing and fans, as well as modding and water cooling-related tools.

JAMES GORBOLD / HARDWARE ACCELERATED

INTEL'S SUPPLY PROBLEM

Production delays, stock shortages and a troubled transition to 10nm manufacturing are all going to push up prices, says James Gorbold

The long-awaited launch of Nvidia's next-gen Turing-based GeForce RTX GPUs is undoubtedly the most exciting story in tech at the moment, but the biggest story of 2018 has to be the massive supply shortages of specific components. It's only been a few months since GPU, PSU and budget CPU supply has returned to normal after the extreme demand and the associated stock shortage and price rises caused by cryptocurrency miners.

Yet now, just in time for the start of the peak season in the run-up to Christmas, there's a massive shortage of many Intel CPUs and chipsets. The problem has been building up for a while and is likely tied into Intel's troubled transition away from its current 14nm manufacturing process to a new 10nm process.

This transition was originally planned for 2016, and has been pushed back several times already, with the latest public information from Intel being that full-scale production will start in late 2019.

The repeated delays have played havoc with Intel's road maps, with new CPUs and processors having to be invented out of thin air and slotted into the missing time slots. That isn't just Intel's problem either. A supply shortage means consumers have to pay more for their new CPUs and motherboards if you can get them at all, as many models simply aren't available any more.

For example, the mainstream Core i5-8400's price has shot up by over £75 in less than a month, a staggering 40 per cent increase, while the high-end Core i9-7900X's price has increased by £100 in the same time period, an unpleasant 12 per cent rise.

It's not just processors either. There's also a shortage of Z370 chipsets, although some motherboard manufacturers seem to be worse affected by this supply issue than others. For instance, there's a good supply of most MSI and Gigabyte motherboards in the channel right now, but many Asus models are out of stock.

The shortage is likely to become even more acute as Intel launches its 9th-generation Core CPUs later this month, for a couple of reasons. For a start, having benchmarked them already, I know they offer a massive improvement over the current Coffee Lake range, although a non-disclosure agreement prevents me from going into specifics. Secondly, we're fast approaching peak season when demand naturally spikes.

It's not just processors either. There's also a shortage of Z370 chipsets

Sticking with that line of thought, it makes me wonder if we're likely to see more or less Intel MDF (market development funds) in this peak season. There's a good argument for Intel not spending as much MDF, as the CPUs and chipsets that are available will likely sell.

On the other hand, though, Intel can't afford for AMD to grow its market share, especially in the profitable gaming PC market. Also, if Intel doesn't get out its MDF chequebook, there will be fewer deals around Black Friday and Christmas.

Interestingly, having initially decided to block the higher-end 9th-gen processors from working on Z370 motherboards, Intel has now had to relax its stance. That's because, even though Z370 is in short supply, there will be even fewer of the new Z390 chipsets to go around. As a result, you'll very soon start to see v2 versions of many Z370 motherboards, upgraded with higher-spec VRMs to cope with the increased power demands of high-end 9th-gen CPUs.

In my opinion, that's quite a pragmatic decision, as the Z390 chipset offers precious little over the Z370 chipset in terms of features, merely adding in native USB 3.1 Gen 2 and integrated 802.11ac Wi-Fi. CPC

James Gorbold has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

CCL COMPUTERS

CCL Nebula

- AMD Ryzen 5 2600 3.4GHz
- 16GB 2400MHz DDR4 Memory
- GeForce GTX 1060 3GB
- 256GB SSD
- 1TB HDD
- Microsoft Windows 10 Home

Custom PC APPROVED

From:

£849.99 Inc VAT

3 YEAR WARRANTY

SPREAD THE COST

FREE, FAST DELIVERY

Configure yours at:

www.cclonline.com/cs-nebula

01274 471 210

pcsales@cclonline.com

Price Match
On all ccl built systems

CCL Computers Ltd, Inmoor Road, Tong, Bradford, BD11 2PS – Prices correct at time of going to publishing (24/09/2018).

XS SYSTEMS PRO GAMING

The Gaming PC Reinvented

GeForce RTX now available in 3XS Systems

NVIDIA GeForce RTX 2080 Ti
Perfect for VR and hi-res gaming

NVIDIA GeForce RTX 2080 Ti is the first GPU based on the amazing new Turing architecture. Sporting 4352 CUDA cores with 11GB of next-gen GDDR6 memory plus support for Real Time Ray Tracing and Deep Learning Super Sampling.

Corsair Vengeance RGB
Stunning RGB, striking speed

Customise the look of your PC with vibrant RGB lit DRAM modules from Corsair. Choose the colour pattern of each module for the ultimate in style and individuality. Optimised for the latest Intel Z370 and X299 motherboards.

Intel® 8th gen Core™ processor family with up to 6-cores

Introducing the new and improved 8th generation Intel® Core™ family. Benefit from up to 50% more cores than previous generation Intel Core processors for additional performance.

Configure your GeForce RTX PC today

scan.co.uk/3xs · 01204 47 47 47

SCAN