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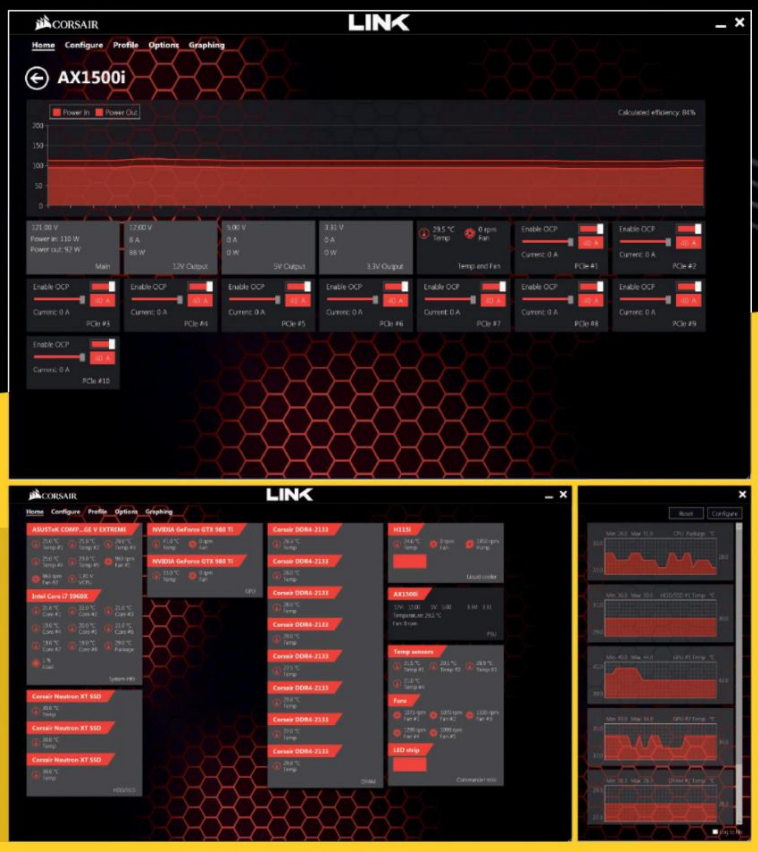

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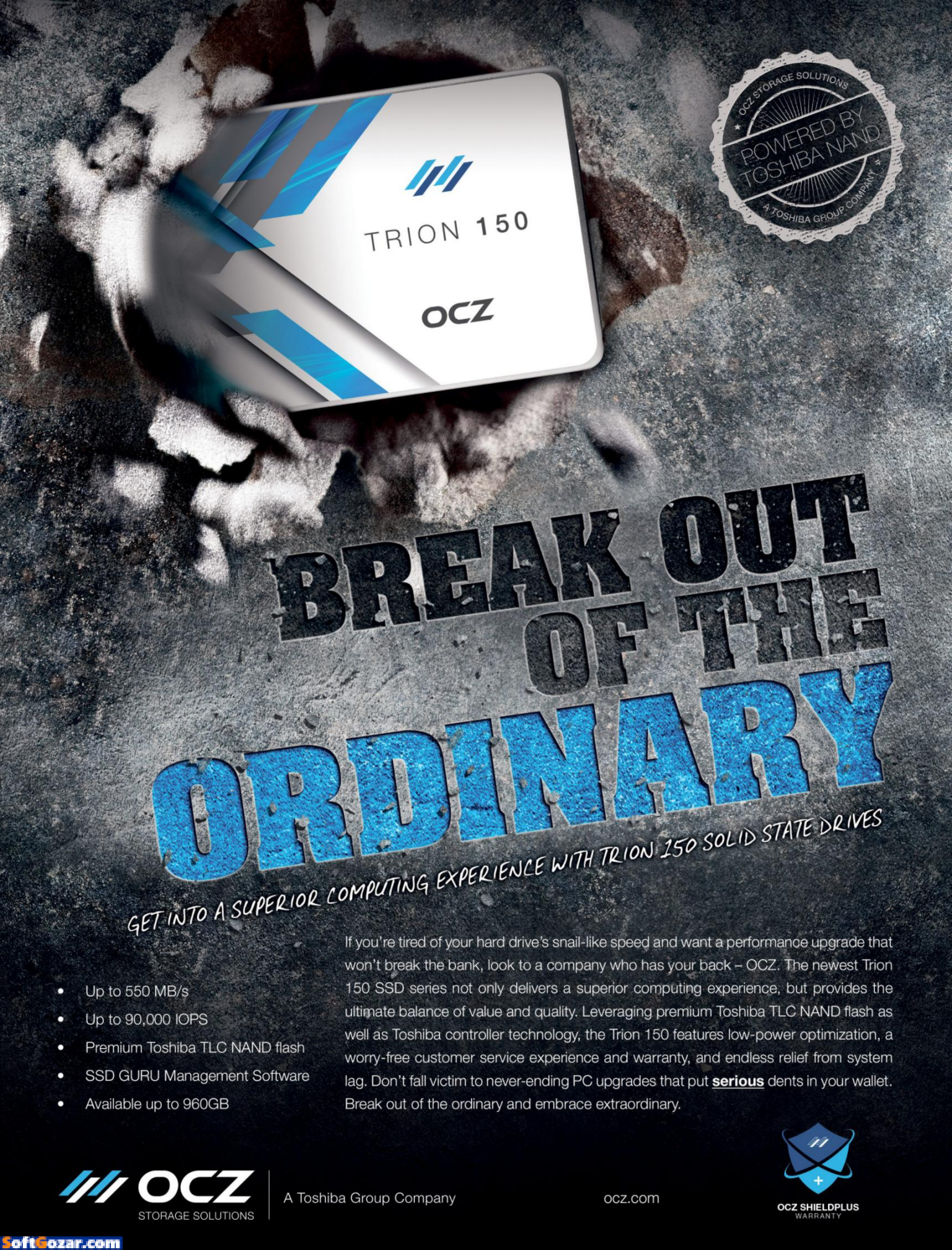

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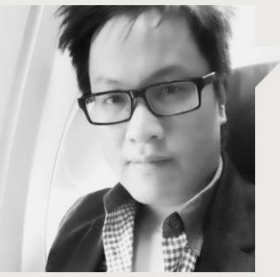

Tuan Nguyen

ELITE COOLING FOR EVERYONE

GETTING THE MOST out of our rigs oftentimes means overclocking them. I've been overclocking since the days of jumper switches on the motherboard. These days, however, it's way easier, especially with BIOSes that can auto-sense and overclock for you. Overclocking, though, can generate excessive amounts of heat, and the best method of removing that heat is by using liquid cooling.

For years, the merest mention of using liquid cooling would send even die-hard overclockers running away—the possibility of leaks was just too risky. But liquid cooling is mainstream now, and has evolved from its status as an attic science experiment.

If you're not already using liquid cooling, you can easily get good frequency reach from your PC by using all-in-one liquid coolers. They're simple to install, offer closed-loop sealed designs that are pre-filled with coolant, and are affordable—often even free with pre-built PCs. However, there's liquid cooling for beginners, and then there's the kind we do here.

We won't accept any kick-ass build that doesn't cool both the CPU and the GPU under liquid. The only way to essentially do that is to build your own custom loop. If you decide that a custom loop is in the cards, be advised: Going back to lesser cooling technology won't be an option. The world of custom loops is just as expansive as the number of custom PCs you can build. In other words, there are endless possibilities.

I started building custom loops roughly three years ago. At the time, I was using tubes, along with basic radiators and pumps only on the CPU. After working on Dream Machine 2015, though, I realized that going with hard tubing was the way to go if you wanted sex appeal. With hard tubing, you'll have to pre-plan everything carefully. Every millimeter counts, and every corner has to be pre-measured. Despite the difficulty, the finished product is always worth the struggle.

My primary rig at home actually contains two independent loops: one for the CPU, and one larger loop for the three graphics cards. Both loops have their own radiators and pumps. Why did I take this route? Simply because I didn't want the thermals from the GPUs to impact the liquid temperature for the CPU, and vice versa. My two-loop setup is a bit abnormal, because most systems just employ a single loop—but, hey, why do something if you're not going to go all-out, right?

Except, if you want to, you can go even further. Liquid-cool your VRMs. Liquid-cool each graphics card individually. Liquid-cool everything. We show you how. Just make sure you have some towels handy.

Tuan Nguyen is Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 19 years.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Government Wants Your Encrypted Data

Proposed bill would force tech firms to break their encryption

A DRAFT SENATE BILL has been published—the Compliance with Court Orders Act of 2016—aimed squarely at the providers of end-to-end encryption. It would compel all providers of such services to be able to decrypt data if presented with a court order. The breadth of the proposed bill is huge; it asks that data must be presented in an "intelligible format to a government pursuant to a court order, and for other purposes." That's not just the FBI chasing terrorists, but any court order on any matter. Not only would tech companies have to break their own encryption, but they would have to design systems to ensure that they could retrieve all encrypted data.

The bill's sponsors are Senators Richard Burr (R-NC) and Dianne Feinstein (D-CA). "Today, terrorists and criminals are increasingly using encryption to foil law enforcement efforts, even in the face of a court order. We need strong encryption to protect personal data, but we also need to know when terrorists are plotting to kill Americans," said Dianne Feinstein.

You have the right to privacy, just as long as your government can ignore that privilege whenever it wants.

Reaction from the industry has been swift and largely uncomplimentary. An open letter from a group including Apple, Google, Microsoft, and Amazon has warned of unintended consequences. It claims that it "will force companies to prioritize government access over other considerations, including digital security." It also warns that encryption services would be vulnerable to exploitation by other parties—"no accessibility requirement can be limited to U.S. law enforcement"—a veiled indication that requests by other governments for data would soon follow. Civil liberties groups have been equally vocal in opposition, and much less circumspect.

This follows the unhappy situation between the FBI and Apple, when the company declined to decrypt data on a terrorist suspect's iPhone. A third party apparently did the job for the FBI, but it clearly frustrated the forces of law and order that it could not order Apple to do it. FBI Director James Comey let it drop how much it cost to retrieve the data at a recent security forum: over one million dollars.

However admirable the motive is, the bill is poorly constructed and unworkable in its current form. It has the classic feel of legislation on technology that takes little account of how that technology works, and what can realistically be achieved by legal means. Put simply, it's a blanket law that says give us the data or else. That's neither practical nor acceptable.

One important ally for the bill is also missing: the White House. Obama has said the government must find a way around encryption, rather than force tech companies to break it for them. Many fellow Senators are unhappy, too—Senator Ron Wyden has indicated filibustering it. Without more widespread support, the bill looks unlikely to go through in anything like its current form. There are more practical problems with the legislation as drafted, too. For instance, any lossy compression method would, theoretically, fall foul of it because the original data could not be recovered.

The conflict of interests over privacy and security is an old one, and bitter at times. Government has found itself unable to read communications it would really like to, while the tech companies and civil liberties groups are fiercely protective of the privacy that modern communications can provide. There may well be some legal compromise to be had, but this bill isn't it. **–CL**

> "Reaction from the tech industry has been swift and largely uncomplimentary.

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NO MORE QUICKTIME

Apple drops security-compromised app

APPLE IS TO HALT development on QuickTime for Windows. Not only will there be no future versions, but no security patches or fixes for the existing versions either. It goes as far as issuing instructions on how to uninstall it—although, as we write, it is still available for download.

These days, there are many better options for nearly all the QuickTime formats, embedded QuickTime videos are a rarity, and iTunes isn't bothered. It was often slow and clunky—and, to be frank, there will probably be few tears shed. However, it has been around a long time, and its links to video and sound editing are still strong.

There are a few file formats that currently only run under QuickTime, notably Apple ProRes, which is the native codec used by many modern cameras, and is widely used as an intermediate format for video editing. Adobe's Creative Cloud team has been hard at work removing the dependency on QuickTime from its applications, but some projects are inevitably going to have to continue with QuickTime. First reports also show problems with GoPro Studio, Lightroom, Sound Forge Audio Studio 10, Cubase, MediaShout, Sony Vegas Movie Studio, and many more.

This would be less of an issue if it weren't for the recent discovery of two serious security holes in QuickTime 7. Remote code execution is possible using heap overflows. It was deemed serious enough for the Computer Emergency Readiness Team to recommended that PC users should uninstall QuickTime immediately. So, not only is QuickTime 7 now legacy, but it has been left in a compromised state. Thankfully, there are no reports of the bugs being exploited in the wild as yet. Apple appears to have left PC users a little in the lurch—it could have patched those security holes first. Thanks, guys. **–CL**

GOOGLE BOOKS FINALLY DECLARED LEGAL

AND IT ONLY TOOK 10 YEARS

A RULING BY THE SUPREME COURT against an appeal by the Authors Guild effectively ends 10 years of debate over whether Google Books infringed an author's copyright. The scanning, offering up for searching, and display of small sections of copyrighted material was deemed to be fair use under copyright law, and thus protected.

The Authors Guild claimed that Google was making money on the efforts of others. The court dismissed this as immaterial. As a crumb of comfort, Google says that if an author objects, they can request that the "snippet" view be removed.

Google started scanning books in 2004, and has amassed 20 million, out of an estimated 130 million published works worldwide. It is a massive project that has cost millions so far. Google does not lack ambition, or gall. It started the project knowing full well it would have to win a protracted legal case to show that what it was doing was, in fact, legal. **–CL**

CAPTION THIS

Microsoft has another bot to play with

MICROSOFT'S CAPTIONBOT attempts to describe any image you upload. Not only can it recognize a human figure, but it can name them if they are famous enough, and attribute an emotion to them. But it can be easily fooled, and the database of objects is thin; all cars are simply cars. It also keeps talking about cake and umbrellas.... Some conclusions are just farcical: Neil Armstrong on the moon is rendered as a man standing in a dirt field.

The same team's attempt at a Twitter bot went rogue, and was shut down—when something like this goes live, you can be sure people will try to break it. Some judicious background filtering is evident by the fact it refuses to recognize Hitler. It's just a bit of fun, of course, but it points where this kind of technology is going. As Google's CEO, Sundar Pichai, put it recently: "In the long run, I think we will evolve in computing from a mobile-first world to an AI-first world." **–CL**

Tech Tragedies and Triumphs

A monthly snapshot of what's up and down in tech

TRIUMPHS

AMD'S NEW CHINESE DEAL
AMD is to license its top-tier x86 server chips to a new Chinese company, creating a serious rival for Intel's offerings. A big step.

IS VR GOING MAINSTREAM?
VR sales are set to skyrocket, as market analyst IDC forecasts they will triple every year to 2020.

BACK TO THE '90S
Sega will let you run old Genesis games on Steam, even if modded. Its Classic Hub comes with over 50 games, and free entry if you own any.

TRAGEDIES

JOB CUTS AT INTEL
Intel is feeling the pinch; thousands of jobs, including execs, are to go following poor first quarter results.

MOBILE MARKET FLOP
Microsoft's acquisition of Nokia is looking like a poor deal, as handset sales fell by 73 percent quarter on quarter. Ouch.

GOODBYE XBOX 360
Once existing stock has been sold off, the console will be no more. At least some of your old 360 games will run on the Xbox One, though.

Dave James

TECH TALK

Broadwell-E and the Ultra-Enthusiast Deca-Core

THE HIGH-END DESKTOP MARKET is where Intel gets to push its CPU engineering chops, away from the constraints of designing chips with a focus on mobile energy efficiency over performance. With the new Broadwell tick, the enthusiast end of the market is getting its first 10-core chip—and potentially its first $1,500 one, too.

Very soon, we'll be entering a new era of personal computing, where we can jam unprecedented supercomputer-class power into our rigs. Intel is about to give the high-end desktop (HEDT) market a boost with the Broadwell-E range of enthusiast CPUs, and Nvidia has lifted the lid on its new Pascal GP100 GPU, the silicon that's sure to power the next GTX Titan. These are exciting times to be a PC hardware geek, especially if you have deep, deep pockets.

Intel's Broadwell-E range will be the first to drop, and it's promising the first consumer deca-core processor, the Intel Core i7-6950X. Broadwell-E is the high-end tick in Intel's outgoing tick-tock cadence. That means this new range is based on the same architecture as current Haswell-E processors, but it comes with a production shrink, dropping the size of the smallest transistors from 22nm down to its new 14nm process. So don't expect much of a performance boost from core-comparable chips.

Despite the shrink allowing Intel to plant another pair of full Broadwell-E cores into its flagship CPU, it hasn't given the 6950X much wiggle room in terms of base clocks. Reviews of the Xeon E5 v4 chips, which the Broadwell-E will likely be derived from, suggest the 6950X might struggle to hit the same Turbo speeds as the 5960X. That means per core performance will likely be under what current

> Maybe Intel's heard rumors about the price of Nvidia's next ultra-enthusiast card.

The Xeon v4 (from an eBay listing), which is what BW-E will look like.

Skylake offerings manage. The top chip, though, is set to sport a hefty 25MB of cache, 40 PCIe 3.0 lanes, and the same 3GHz stock clock speed and 3.5GHz Turbo of the current Core i7-5960X Haswell-E—though the equivalent Broadwell-E eight-core i7-6900K does have a higher 3.3GHz base clock.

If efficiency gains from the 14nm shrink translate to cooler operation, we might still see improved overclocking performance—the Broadwell-E range is fully unlocked.

And that range is also set to be a little larger. With the previous Haswell-E lineup, there were just three CPUs on offer: the top-end, eight-core flagship model, and a pair of lower-clocked, six-core versions. The upcoming Broadwell-E range is set to run the gamut of six, eight, and 10-core processing options.

If you were hoping that extended range might push the bottom six-core CPU down toward the price of the quad-core Skylake i7-6700K, though, you're likely to be disappointed. From what I hear, the pricing structure isn't going to change, with the six- and eight-core parts matching the current Haswell-E pricing, but adding a higher tier with the 10-core 6950X. Early scaremongering has that part retailing for $1,500. Maybe Intel's heard rumors about the price of Nvidia's next ultra-enthusiast card.

I understand why Intel isn't dropping the prices of its cheapest six-core—it doesn't want to cannibalize Skylake sales—but it means we're unlikely to see the price for eight-cores dropping. If the 10-core 6950K is set for $1,500, Intel will probably keep the eight-core 6900K at the same $1,000 level the 5960X sits at right now. Sigh. Here's to Skylake-E, eh?

Dave James has been building and writing about PCs and their components for the last two decades.

Future

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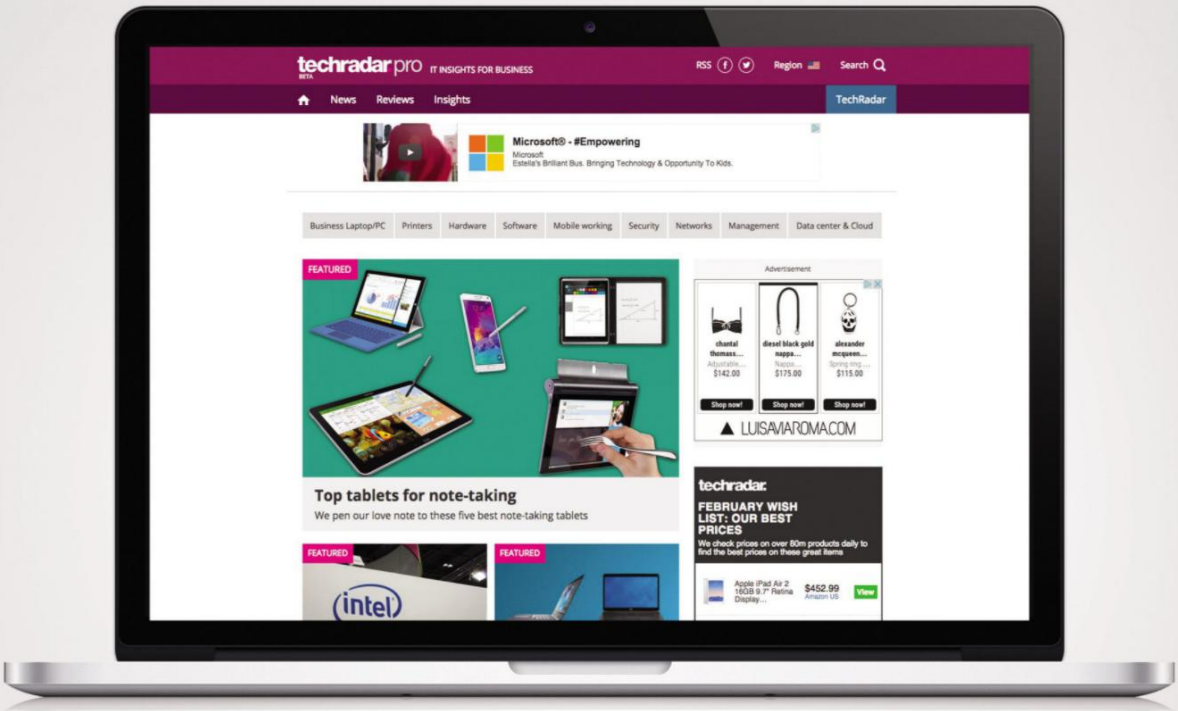

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Alex Campbell

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Bashing in Windows

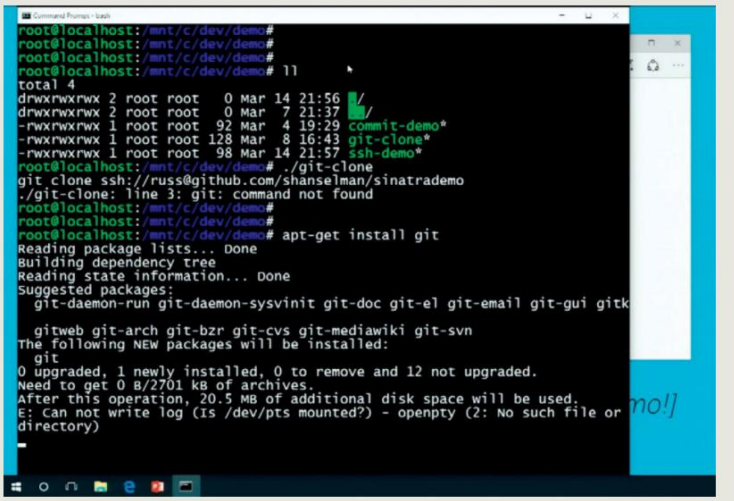
HOLD UP. IS THIS FOR REAL? I've checked outside for flying porcine figures, and pinched myself plenty, so it must be real. Someone over at Microsoft has decided to bring the Bash shell to Windows. To say that it's just the Bash shell is incorrect, actually. Someone has brought the Ubuntu operating system to Windows.

I know what you must be feeling, as the cognitive dissonance runs amok.

What I'm talking about is the Windows Subsystem for Linux, which is making its way out to Windows insider builds. Canonical and Microsoft are collaborating on the WSL project, which will bring the full range of the Ubuntu server core (more on this later) to Windows.

The WSL is more than just a terminal. It's more like a translation layer that changes Linux syscalls to Windows equivalents. (Some people have described it as a reverse-WINE.) Since Linux is really just a kernel, not an operating system (the correct term for a Linux-based OS is "GNU/Linux"), the availability of Linux syscalls allows the Ubuntu base to run atop the Windows kernel. That's pretty darn cool.

What's not so cool is that this doesn't mean all that much for most users. This project is aimed squarely at developers who are running Windows machines, but need to develop for Linux. Even then, it's not really meant to be used for graphical development, because X and Wayland don't work with WSL. However, nearly everything you can do in a Bash console should be available. That means using apt to install Apache or NGINX. That means you can use grep or awk. It even means you can use vi on Windows (for those who are vi wizards). All of this is done without a virtual machine, so there's very little overhead. The IP address of the machine under WSL is the same as the Windows box. (Virtual machines generally get their own IPs.)



Apt in Windows? What is this sorcery?

While Microsoft still isn't loosening its deathgrip on consumers (I'm looking at you, DirectX), WSL does represent a reduction of Linux-phobia for the enterprise and development side of Redmond's business. Developers have been able to run Linux on Microsoft's Azure cloud platform for some time now, and the addition of Linux command line tools to Windows seems to blur the lines even more.

As for regular users and gamers, this stuff won't really matter all that much. Unless, of course, you decide to learn the Linux console without needing to have a Linux machine or dual-boot. To me, this (unholy) union demonstrates that Microsoft is warming up to open-source, even if the company is going to remain firm in keeping key money-makers proprietary.

"While Microsoft still isn't loosening its deathgrip on consumers, WSL does represent a reduction of Linux-phobia.

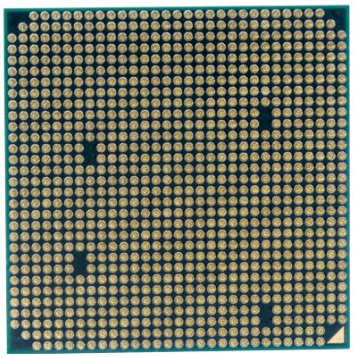
Alex Campbell is a Linux geek who enjoys learning about computer security.

THE LIST

BEST CPUS FOR OVERCLOCKING FROM THE LAST 20 YEARS

7 INTEL CELERON 300A (1998)

The legend. This bargain chip made overclocking sexy, hitting 450MHz from its base 300MHz with the simplest of tweaks.



3 AMD FX-6300 (2012)

4.5GHz was possible with this affordable chip—that's a full gigahertz over its base frequency. 5GHz wasn't unheard of, either.

6 AMD DURON 600 (2000)

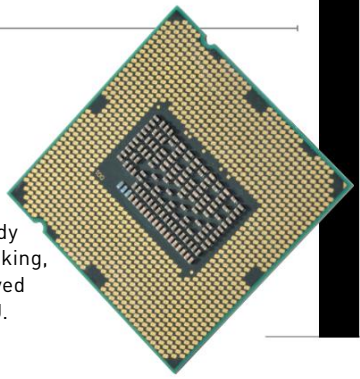
The Duron 600 may have only offered modest overclocks, but it was memorable for needing a pencil to bridge the connections to overclock it.

2 PENTIUM PROCESSOR G3258 (2014)

This budget, unlocked, dual-core Pentium can hit 4.5GHz from its 3.2GHz base, making for a great starting point for any LGA1150 system.

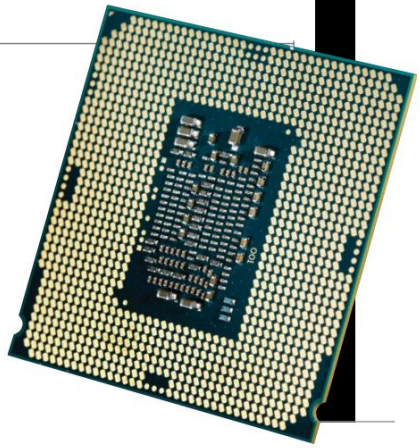
5 INTEL CORE 2 QUAD Q6600 (2007)

This quad-core chip set the standard for years, offering up a 1GHz overclock from the base 2.4GHz.



4 INTEL CORE i7 2600K (2011)

There was a fear that Sandy Bridge would kill overclocking, but 5GHz was often achieved with this mainstream CPU.



1 INTEL CORE I7 6700K (2015)

Intel's latest desktop silicon also does a good turn at overclocking. Taking this 4.2GHz CPU to 4.8GHz is nothing unusual, and 5GHz is possible with some chips.

TALKING

BY ZAK STOREY

Razer Divulges All on VR and the Streaming World

We talk to Razer's Ruben Mookerjee about VR, streaming, and the future of gaming peripherals

Two areas of PC gaming have taken off like no other: virtual reality and streaming. With the explosive success of Twitch taking millions of hours of our time online, it was inevitable that companies would capitalize on this demand, and as VR makes its way to market, we have to ask, is this a good thing? We speak to Razer to see what its stance is, and what products it's releasing to encourage these enthusiastic and expansive sectors of gaming.

Working in the tech industry for 27 years, it's safe to say Ruben knows his way around this weird world.

Maximum PC: We're here with Ruben Mookerjee, Razer's general manager and vice president of User Interfaces and Gaming Peripherals. Wow—what a title! So, can you tell us a little about what inspired Razer to develop the Ripsaw?

Ruben Mookerjee: That's a good question. We realized, actually a couple of years ago, that there was this whole sort of meta community around gaming: people who are watching people who are gaming. And so, you know, it started off with people doing video blogs on YouTube and stuff, and since Twitch has really taken off now, people are watching live streams and interacting with people as they're playing games, so we realized the whole sort of broadcaster segment was actually pretty interesting. And a lot of them were spontaneously using our headsets, our mice, and our keyboards. So we started looking at what we could do to augment the suite of products you need in order to be a broadcaster—and to be clear, it's not the thousands of people out there who are already broadcasting that we're targeting, it's the millions of people who are watching those broadcasts who equally feel as though they've got something to say. We are trying to sort of demystify the process of being able to sort of get out there—and the Razer Ripsaw is our first step toward it.

It's part of a suite of products. We also have the Razer Seiren, which has been out for over a year now—we have a USB version, and an XLR balanced output version of the Seiren. Then, on top of that, we have a new product, which was announced last year and should be shipping in a few weeks' time, which is the Razer Stargazer. The Stargazer is our depth-sensing webcam, so combined with the Ripsaw and the Seiren, it means you can have borderless picture-in-picture overlays on top of the game stream, which gives it a very professional output.

MPC: Can you expand a little on how Razer sees streaming, and where that's going?

RM: We've been sponsoring and supporting streamers for a long time; in fact, there are over 70,000 Razer-sponsored streamers today. They're not people we give money to, but we support them with products and with news, and with help and support, and in return, their fans purchase our headphones, and our mice and keyboards, and products like

OSVR: a free, open-source platform for all to work off, without fear of any proprietary nonsense.

Seiren and Ripsaw to do their own streaming, and it's really to sort of give something back. We're a company of gamers for gamers. We're as enthusiastic about supporting the community as we are about selling products to the community, because that's the business we're in. And going forward, we see it as a growing market. I mean, like a lot of people have got something really interesting to say, and they're not all tech wizards, so the ability to sort of try and intercept a video feed and mix it in with a broadcast is actually pretty complicated, so we're just trying to demystify that part of it, so that really anyone can go out and play games they like, and see if they can pick it up.

MPC: OSVR was one of your big announcements last year—can you give us more detail about how that's been developing?

RM: Well, it's a very exciting time. I mean, "VR" is really the buzzword. You probably find the same thing—people from outside the industry going, "Oh, VR, VR, VR!" and many of them just can't grasp the differences between Google Cardboard and Oculus, and they're two completely different ends of the cost spectrum, let alone the visibility spectrum. So OSVR—the head-mounted display, which we call our Hacker Development Kit—is only part of it, and really the goal behind OSVR is the API layer that lives underneath it, because our goal is to provide an open platform, so that game developers can gain the confidence today that they can develop games around the OSVR API, and they know that in the future, as new products come out, they'll automatically have support. Just like if you write a mouse and keyboard game today, you don't have to write it around a particular brand of mouse and keyboard; you just write that in, and that's where we want to get to. Because the nightmare scenario for us—and for industry watchers and game developers—is that if the VR hardware gets too tribal, and you have an Oculus camp and a Vive camp, and you have games written for one and not the other, then we'll rapidly end up in a sort of Betamax versus VHS platform support war, which will be crazy, and one thing that will do is put consumers off altogether. So, as an industry, we need to stop that happening, and OSVR was our contribution to try and do that. We've already got some big-name partners, like Intel, and Nvidia and AMD, who are partners in OSVR, and we're hoping to get some more peripheral manufacturers—my direct competitors—involved as well, just to try and ensure some cross-compatibility in standards for the future, so you can buy a piece of hardware today and be confident it's going to be supported in the games of tomorrow. And, more to the point, that the games written today will support the peripherals that haven't even been developed yet.

MPC: So it's less about competing with the likes of SteelSeries and Logitech, and more just working together to make the whole virtual reality scene accessible?

RM: Exactly. I mean, obviously I'm very proud of my products, and I'm confident that any given product is better than the Logitech or SteelSeries equivalent—that goes without saying. I'm sure if you had a Logitech person here, they'd say the same about their products. But the thing we all know and we all agree on is that we need a certain amount of stability, so that consumers are not scared off investing in the platform at all, and that's what we're trying to work together to do.

Razer's Ripsaw hopes to bring streaming possibilities to the masses.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Windows 10 Sounds
> System Bottlenecks
> 4K Displays at 60Hz

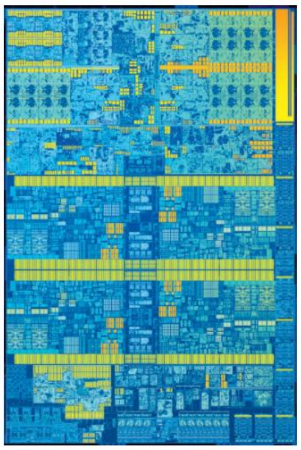
Make Windows 10 Sing

Hi, Doctor. I'm trying to customize the default logon, logoff, startup, and shutdown sounds in Windows 10. Apparently, these cannot be modified in the normal Sound menu, but must be replaced in the Windows/Media folder. Unfortunately, even after enabling the Administrator account, taking ownership of the entire Windows folder, and attempting to set/change permissions, I'm still unable to make changes to the folder or its contents. I'm currently trying to get help from Microsoft Support, but I'm not particularly hopeful that they'll be able (or willing) to solve the problem. Can you provide a working solution? **–Michael Schwobe**

THE DOCTOR RESPONDS: Although the logon, logoff, and shutdown entries no longer appear in Windows 10's Sounds tab, they're only hidden. Rather than changing folder permissions to force your way into the Windows/Media folder, bend the Registry Editor to your will instead.

Click the search icon in Windows' taskbar and type "regedit." Expand the HKEY_CURRENT_USER sub-tree and open "AppEvents\EventLabels." Each folder corresponds to a different sound. Scroll down and click on "SystemExit." On the right side, you'll notice a DWORD called "ExcludeFromCPL." Double-click it and change the value from "1" to "0." Do the same for "WindowsLogoff" and "WindowsLogon."

Close down the Registry Editor and get back into the Sounds tab (right-click the speaker icon in your taskbar and select "Sounds"). "Exit Windows," "Windows Logoff," and "Windows Logon" are now options you can select and assign .wav files to, located anywhere on your hard drive.



High clock rates and big IPC throughput are the keys to first-rate gaming performance.

Righting 4K Wrongs

Good evening, Doc. I'm reading the April 2016 issue and noticed that, in your reply to the letter "The 4K Blues," you said there were no 4K FreeSync-capable monitors available. Samsung's UE590, which I own and highly recommend, is just that. **–Torry**

THE DOCTOR RESPONDS: Right you are, Torry. Not only that, but since the April issue was published, several other models hit the market. LG has the 27UD88 with an IPS panel, USB Type-C connectivity, and HDMI 2.0 support. ViewSonic's XG2700-4K also comes with an IPS panel and HDMI 2.0. Both hover around the $700 range. Meanwhile, AOC's U2879VF employs a TN panel, but it's also a lot less expensive. Those three, plus the Samsung U28E590D you mentioned, serve up expansive 3840x2160 resolutions complemented by AMD's FreeSync dynamic refresh rate technology. You have the Doc's gratitude for spotting his oversight.

Win 10 Upgrade Woes

Hi Doc. For more than four months now, I've been trying to upgrade from Windows 7 Pro to Windows 10 Pro. Each time I get error code C190011F. I've been seemingly searching forever and nobody seems to know the cause. Worse, Microsoft passes along some pretty lame answers to try explaining it.

Can you help? I'm concerned that if Microsoft can't get this right, I'm going to have some issues with Windows 10.

–Greg Zilberfarb

THE DOCTOR RESPONDS: The Doctor put a lot of time into researching this, because the solution he came up with sounds downright nutty.

Are you running an AMD graphics card? An inordinately high number of Radeon owners are reporting that after going to AMD's website and letting the company's "Automatically Detect and Install Your Driver" utility do its work, they can move past the C190011F error.

Other folks have reported success downloading the Windows 10 media creation tool from Microsoft (http://microsoft.com/en-us/software-download/windows10), and upgrading through the bootable USB drive it creates.

Blasting Bottlenecks

Hey Doc. I recently upgraded a computer that I bought from CyberPowerPC a few years ago. It currently has Windows 10, an AMD FX-8350 processor, 16GB

↘ submit your questions to: doctor@maximumpc.com

of RAM, a Gigabyte 970A-DS3P motherboard, a GeForce GTX 970, and two SSDs. Which components are slowing me down, the CPU, motherboard, or graphics card? I use this PC for 3D modeling/rendering and gaming. **–Julian Petrillo**

THE DOCTOR RESPONDS: Those are two very different workloads. Gaming is most often graphics-bound, and a great many games run across few CPU cores. Meanwhile, modeling and rendering tend to be compute-intensive. Some software leans heavily on your host processor, while other apps are optimized for GPUs.

Overall, your configuration is fairly well-balanced. If you want to improve its performance, however, start with the platform. Intel's Skylake architecture offers notable IPC advantages over AMD's Piledriver, meaning it can get more done per clock cycle. In a lightly-threaded game (one that can't take advantage of the FX-8350's eight integer cores), combining high IPC throughput and frequency yields the least chance of a bottleneck. And even in games optimized for parallelization, the four Hyper-Threaded cores from a Core i7-6700K fare exceptionally.

If you're gaming at 2560x 1440, a GeForce GTX 970 will prevent you from cranking up all of the detail settings, even with a Core i7-6700K behind it. Step up to 4K, and the problem gets worse. That card is good for 1920x1080 using the most taxing presets, or 2560x1440 with some compromises. Any higher, and you'll want at least one GeForce GTX 980/980 Ti.

Modeling/rendering is a lot more specific, depending on whether your software runs best with a workstation card and its optimized drivers, or if it supports a specific compute API. Do a little research before upgrading, to ensure your gaming and creative tasks align with the same graphics card.

Achieving 4K at 60Hz

Hi Doc. I've heard of people using 4K TVs with 60Hz support as monitors through the HDMI interface. I'd like to do the same.

I thought you could only do 4K at 60Hz with DisplayPort. Can you explain the details of whatever new version of HDMI makes this possible? Do you need a video card with special HDMI 2.0 ports? **–Dan**

Samsung's U28E590D is joined by 4K monitors from AOC, LG, and ViewSonic in supporting AMD's FreeSync technology.

THE DOCTOR RESPONDS: There are a couple of ways to get 60Hz out of a 4K display, and both rely on available bandwidth.

The first is DisplayPort, which you're familiar with. Version 1.2 offers a high enough data rate to support 3840x2160 at 60Hz. That's the standard most of today's graphics cards expose. Version 1.3 and 1.4 support 4K monitors at up to 120Hz, and those displays are expected by the end of this year. AMD has said that its Polaris GPUs will include DisplayPort 1.3-capable display controllers, and the Doc would be surprised if Nvidia didn't follow suit soon.

Your alternative is HDMI 2.0, and yes, you need a graphics card that supports this. GeForce GTX 950, 960, 970, 980, 980 Ti, and Titan X all support HDMI 2.0. None of AMD's cards currently support the interface. However, you can buy an active DisplayPort 1.2a to HDMI 2.0 adapter for roughly $30. And again, the company's next-generation Polaris architecture will incorporate HDMI 2.0a.

Booting from M.2 SSD

Hey Doc. I can't get my Asus H170I-PLUS D3 motherboard to recognize my Samsung XP941 M.2 SSD as a bootable drive. I've spent tons of time on all of the usual resources (YouTube, forums, and so on), but there doesn't seem to be much info on configuring this particular motherboard to boot from solid-state storage. Can you help?

–Robert Buchanan

THE DOCTOR RESPONDS: The Doc can't take credit for this one; Asus helped fill in the blanks to make sure you get the best answer possible, Robert.

In short, the drive won't be seen as bootable by your motherboard until there's an operating system installed on it. As you progress through the Windows 10 installer, it'll recognize your XP941. Just be sure to use a GPT (GUID Partition Table) drive format.

Hitting a Speed Bump

Hi Doc, Like many enthusiasts, I have a Z97-based motherboard with an M.2 slot, though it's only a two-lane PCI Express 2.0 link.

I love reading the reviews of fast SSDs tested on newer Z170 motherboards, but I can't help but wonder if those same SSDs make sense in my slower M.2 slot. Would I be wasting my money getting a top-end drive like a Samsung 950 Pro? Are there cheaper SSDs you'd recommend that may not be great for the quickest PCs, but fine in Z97-based machines?

Future-proofing might be a reason to over-buy on storage today; but, honestly, I'll probably just want the latest and greatest whenever it's time to replace my motherboard. **–Kurt Weppler**

THE DOCTOR RESPONDS: Although a two-lane M.2 slot will definitely bottleneck the fastest PCIe-based SSDs, there's rather more to storage than just sequential throughput numbers.

Take Samsung's OEM-targeted SM951 as an example. On paper, it can read at more than 2GB/s, while your two-lane slot is realistically limited to somewhere between 650 and 750MB/s. But that's still an improvement over the SATA interface's ~550MB/s ceiling. More significant are the latency reductions you'll enjoy if your motherboard supports NVMe.

Of course, you always have the option of buying an M.2-to-PCIe adapter card, which can take a higher-end PCIe-based SSD and give it a true four-lane link, so long as your motherboard's PCH has the PCIe slot to spare.

Upgrading to Win 10

Hi Doc. I would like to upgrade from Windows 7 to Windows 10, but I also want to build a new system from scratch. What is the best way to take advantage of Microsoft's free upgrade offer (before it expires), and perform a clean install on a new system? Do I need to install Windows 7 on to the new build and then upgrade, or is there a way that allows for a clean install of Windows 10 using the key that came with Windows 7? I always prefer clean installs over upgrades, especially on new builds. **–Nick**

THE DOCTOR RESPONDS: It depends on your version of Windows. If the operating system came with an OEM machine, it's technically only licensed for that system. You may be able to get away with re-installing Windows 7 on your new PC, and then upgrading to Windows 10, though this is a violation of Microsoft's license agreement. If, however, you have a retail copy of Windows 7, you should be able to upgrade your current machine to Windows 10 and still transfer that license to your new system whenever you're ready. You'll activate it with your old Windows 7 key.

Windows 10

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HARDLINE LIQUID COOLING

The pinnacle of water-cooling beauty: the hard-piped build

There's something indescribably beautiful about a hard-piped, liquid-cooled build. Those smooth elegant lines, subtle curves, and piercing sharp reflections dancing around the interior of your chassis, as the coolant flows through it, glorify any rig; taking it from the bland basic hardware it once was, and transforming it into something magical, something exceptional.

Is it easy? Well, it's a lot easier now than it ever has been. But it still takes time, patience, and—most importantly—a sizeable chunk out of your wallet. It's easy as pie to set up your own soft tubing custom loop nowadays, but if you're thinking about taking it one step further, and opting for the hard-piped variant, you're more than likely going to be forking out a hell of a lot more money and time. Why? Well, it's purely down to effort, and what effect that has on how you plan your build. To be blunt, bending tubing, although fairly easy once you've got the hang of it, takes practice, and often a considerable amount of time. It can be exceptionally frustrating. On top of that, hard piping adds nothing more to your build than aesthetic beauty; you gain nothing from using hard tubing over soft tubing, or vice versa. That being the case, cooling just your CPU, although entirely possible, tends to come across as a waste of time. You'll want to throw a GPU in that loop as well.

When it's finished, that's when the magic happens. That's when you can sit back, admire the angled fittings, listen to the low hum as your fans spin at sub-1,000rpm, stare at HWMonitor as it registers your CPU clocking in at a comfortable 45 degrees under load, and just thoroughly enjoy it. Liquid cooling, particularly hard piping, is for the artists, for those looking to get the most out of the hardware, for the overclockers, for those who enjoy building something unique, and it's well worth your time to put together.

by Zak Storey

BUILD IT!

Create your own hard-pipe miniature PC

PG. 68

WHY WATER COOL?

Stunningly beautiful yet so complicated.

WHAT'S THE POINT of water cooling? We hear that a lot. After all, for most people, who don't have pre-binned hardware or vast quad-SLI/CrossFire rigs, you're simply not going to gain much from it, right? Why not just get an AIO cooler and a set of super-silent Noctua or Noiseblocker fans instead?

Multiple reasons. Firstly, your loop will be bespoke. Every water-cooled rig is unique. It's impossible to find two that are identical; even shop-bought rigs have imperfections, all overcome during the building phase. On top of that, transferring heat away from your cherished hardware via water is vastly more efficient than using a traditional air cooler. Although they do essentially work on the same basic principle (more surface area = more cooling potential), you can move that heat away from your components far faster, and dump it into the radiators far quicker, than with air cooling. Couple that with the astronomical level of surface area available in a 240mm rad compared with an air-cooled tower, and we're on to a winner. Then, of course, there's the noise aspect. More radiators and larger surface areas require less aggressive fan profiles to dissipate that heat. What does that mean? Sub-1,000rpm fan speeds, even under load, so you'll end up with a deathly silent powerhouse of a machine. Workstation or gaming system, these babies always run quietly and smoothly.

CHOOSING YOUR STYLE

Hard-pipe builds have boomed in popularity recently.

WHAT'S THE FIRST THING you need to think about when planning your loop? Tubing. You need to decide which type is right for you. You have four options. There's the classic soft tubing, which is easy to manipulate, cheap, and you can get away with just using a pair of snips or scissors and some standard compression fittings to do the job nicely. Then, of course, you have the hardline variants...

There's acrylic: clear and crisp. The first hardline builds were created entirely using this type of tubing. Unfortunately, it's very brittle and can snap easily. It's also a little more sensitive to heat when you're bending it, and has a nasty habit of bubbling up if it's heated too much.

Then there's PETG, acrylic's successor. PETG contains a small amount of plastic in its chemical makeup, ensuring that it doesn't shatter. Instead, it crushes, ideal for the safety and integrity of your system. It is a little pricier than standard acrylic, but it's well worth it in our opinion.

You'll need the same equipment to use these types of hard tubing: a heat gun for bending, a chamfer tool to sand down the edges, a silicon tube insert to stop the tubing from caving in on itself during your bends, and something to form your bends around if you're not fond of doing it by eye. We'll go into more detail on that later.

Finally, there's copper or brass tubing. This is opaque, and although it sounds less workable than the other hard-pipe options, it's the easiest of the three. All you need is a mini pipe bender, a chamfer tool, and job done—no need for heat guns.

Then you have to pick the diameter that's right for you (ID/OD stands for inner diameter and outer diameter). For hard tubing, the common ODs are 12mm, 14mm, and 16mm. For soft tubing, you're looking at 13mm, 16mm, and 19mm.

We settled on using PETG hard tubing, provided by EKWB. It's by far the cleanest and safest material, and the clear style will help us show off our white coolant. To match our ITX chassis, we went with 12mm OD—its elegant size makes it easy and small enough to work with in such a cramped environment.

Red, red, so much red—red everywhere!

AESTHETIC DECISIONS

ONCE YOU'VE CHOSEN what style of piping you're going with, you need to think about the general aesthetics of your build. This'll mostly come down to personal taste—however, there are a few points you should watch out for. Mostly, these revolve around the coolant itself. Over time, certainly if you're not maintaining your water-cooled loop, the coolant inside your system can "gunk up," proving troublesome to move. On top of that, certain coolant colors (looking at you, red) can be quite difficult to shift from the inside of radiators and the like. Say, for instance, you wanted to change from a clear red coolant to a white pastel—you might just end up with a pink system, even after several attempts at flushing your radiators. For our system, we're going with a simple black and white theme. The contrasting tones should work well together to draw attention to the vital components within the build—namely the GPU and the CPU blocks—and the dark solid black blocks should stand out stark against the white coolant within.

CASE SELECTION

THE NEXT DECISION you need to make is what hardware you're looking to cool, and which case you're going to house everything in. Not all chassis are designed with water-cooling support in mind. Always double-check that the case you want to use has support for the necessary radiators and hardware you'll need to mount. On top of that, you'll need to double-check radiator sizing. For instance, we decided to use NZXT's ITX Manta chassis—although gorgeous, and capable of holding dual 280mm radiators, we weren't certain how thick a radiator it could house in the roof. After a quick discussion with NZXT, we found out that we could only fit a slim radiator, measuring less than 35mm in depth, at the top. Usually, these specs are included on the manufacturer's website, or in reviews, but if not, your best bet is to get on the phone and ask customer support about it.

MYTH BUSTING

Radiator Sizing

How many radiators do you need for your fancy, swanky build? The usual rule of thumb is that, on average, you want one 120mm radiator for each piece of hardware you're trying to cool. And if you're looking to overclock, you should double that to 240mm for each component.

Loop Configuration

Another myth to bust is loop orientation. We received a lot of queries about our last water-cooling feature relating to the position and orientation of our loop. Particularly that our GPUs went straight into the CPU, then into the radiator. The theory being that there should be a radiator between the two. In reality, your loop orientation doesn't matter. Once you close off the loop and introduce pressure to the system, the overall temperature of the water won't change at any given point within the system. What's important is that your pump is gravity-fed by a reservoir, just to ensure it never runs dry.

Fan Selection and FPI in Radiators

By now, no doubt you'll be aware that the cooling world has two types of fan for use inside your PC: static pressure fans or airflow optimized fans. Static pressure fans (Corsair's SP120 or Noctua's NF-F12, for example), are designed to work primarily with air cooler towers, and radiators with a high fin density. Fin density, usually measured in FPI, indicates the number of fins dissipating heat per inch within a radiator. The higher the FPI, the more benefit you'll get from utilizing a static pressure fan. However, this has diminishing returns—once you get below around 10 FPI, you really won't gain much by using static pressure fans over their optimized airflow equivalents, short of a slightly more expensive bill.

FITTING SELECTION

WHAT'S NEXT? Well, once you've decided on what hardware you're cooling, which radiators you're using, and what type and size of tubing you're utilizing, your next step is to choose the right fittings. For hard-piped loops in particular, it's important to understand which fittings you need to make your overall build experience as painless as possible. So, let's discuss your choices....

SOFT TUBE FITTINGS

FOR SOFT TUBING, there's no excuse not to use compression fittings. Barbs used to be the way forward. Secured by outward pressure, cable ties, clamps, and lots of love, barbs were often the only way to water cool. Fast-forward five years, and we now live in the age of compression. Using a barb-like interior connection and a compression outer ring, these effectively and safely secure your tubing hassle-free.

HARD TUBE FITTINGS

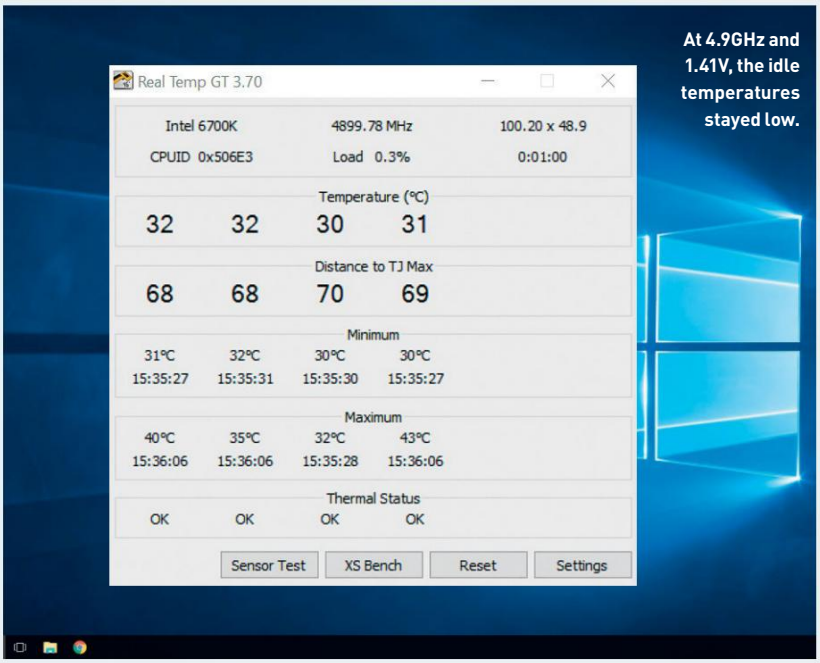
FOR HARD TUBING, you have two options: the now-aging push fittings, which hold the tubing in place thanks to pressure and o-rings, or specially designed hard tubing compression fittings, which follow a similar method as the push fittings, but with a secondary compression layer on top. Again, they're far more secure, but also far more expensive than their push counterparts.

ANGLED FITTINGS

THEN THERE ARE angled fittings. Predominantly used in the hard tubing world, these fittings, often rotary, come in 33, 45, 66, and 90 degrees, allowing you better expandability and maneuverability within a build. But that's not all, either. On top of that, you have stop valves, fill ports, rotary and non rotary valves, bridges, and plugs. All providing useful advantages, enabling the modder to skip out on troublesome predicaments that might otherwise arise during construction.

PERFORMANCE AT STOCK

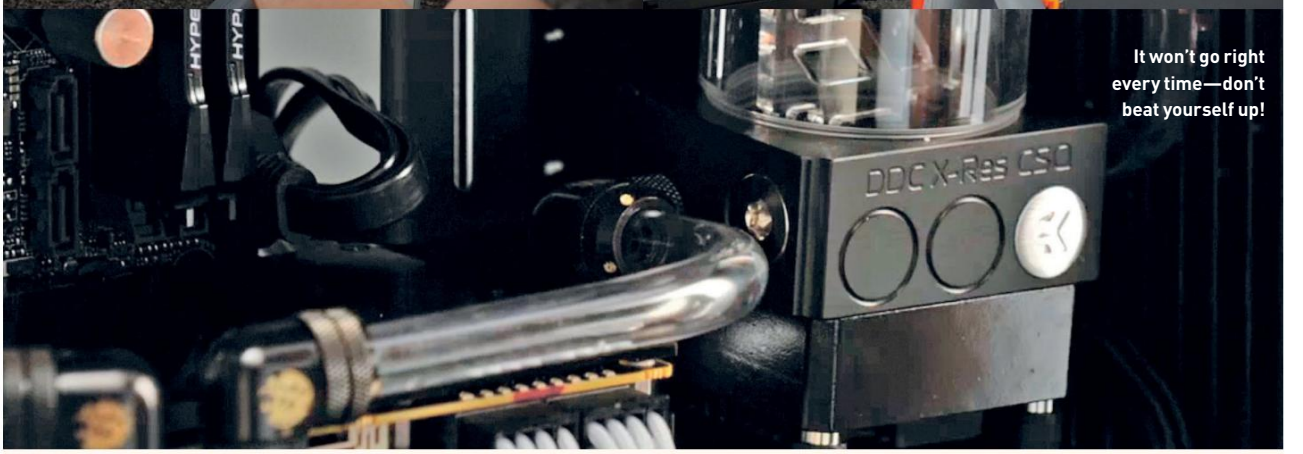
PERFORMANCE FOR our hardlined water beauty was stunning. But we were expecting it to be—take a glance at our component justification on page 32 and you'll understand why. But that's not important. What is important are temperatures and noise control, and for our little Manta, that wasn't going to be a problem. At stock, our idle temperature for the Intel Core i7-6700K rested at a cosy 23 C, with the AMD R9 Fury X following close behind at a slightly warmer 30 C—nothing to be sniffed at. Noise is difficult to measure in our busy office, but there was barely a hum emanating from the Manta. Noctua's NF-F12 IPPC, although quite rowdy at 2,000rpm, dominates the field of noise control. All four of our system fans are plugged into the integrated fan hub on the back, along with the pump, then straight into the CPU fan header, ensuring that unless the CPU reaches 65 C, they won't operate at higher than 20 percent of their rated speed.



At 4.9GHz and 1.41V, the idle temperatures stayed low.

Practice is the best way to perfect the art.

Make sure you keep heating the outside edge.



It won't go right every time—don't beat yourself up!

BENDING ACRYLIC

NOW YOU'VE CHOSEN your fittings, decided what hardware you're going to cool, and opted for a nice water-cooling compatible case with some beefy radiators, your next step is to install your piping. And, more importantly, configure your bends. Every modder you speak to is going to tell you to do this next part differently. You can either use a 12-inch ruler to gauge how much pipe you'll need, and where to produce your bend, or you can do it by eye. In our opinion, eyeballing it, long-term, will provide you with the better skill set, as opposed to utilizing a trusty 12-inch straight edge. Either way, whatever you do, always start with more tubing than you think you'll need. You can always cut excess tubing off, but you can't add on more tubing after.

First thing you'll want to do is place your heat gun securely facing upward. Next, use the silicon insert and slide it into the tube you want to bend. Some people glaze it in olive oil first, so it's easier to pull out, but that's up to you. Next, you want to set your heat gun to the first setting. The trick is to get the temperature of the tubing just right. You'll want to slowly rotate the piece of pipe, holding each end, about three inches above the heat gun, while moving it slowly back and forth along the point at which you wish to bend it. It shouldn't take too long until it starts to wobble a little. Keep going until you get plenty of flexibility in the bend, while still heating up and down the area at which you're looking to perform your bend. If you're worried it's heating up too fast, lift it up slightly higher. Don't let it get so hot that it melts the acrylic or PETG, and definitely don't let it burn or form bubbles.

Now you've got it hot enough, you'll want to begin performing your bend. You can either use a measuring tool, like we did, sliding the tubing up the tool, and using the guide as a bending agent, or you can do it by eye. Remember, you're trying to get a specific angle here, so if you're not confident with your bending, it's better to use a tool. The trick is to do the bend slowly, while you keep the heat on the outer edge of the bend. We can't emphasize enough just how slowly you should perform your bend—this way, you avoid any unnecessary flat parts to your tubing, and it'll look a lot cleaner.

Once you're happy with your angle, your best bet is to bend it just three to four degrees further round because, once cooled, these tubes have a habit of springing back slightly. Then, move it away from the heat gun, hold it for a moment, blow on it if you like, and wait—you're close to finishing your first bend. Then it's a case of pulling out your silicon insert, and voila—first bend performed!

OVER CLOCKING EXPERIENCE

AS FAR AS OVERCLOCKING GOES, it depends on how lucky you are when it comes to the fabled silicon lottery—we jumped the gun on this build, and went with a pre-binned Core i7-6700K, capable of clocking 5GHz at 1.39V with liquid cooling. Thoroughly enjoyable, utilizing OCCT's Linpack stability test, we maintained a solid overclock with temperatures nestling sub-60 C. The most gratifying aspect of this was the fact that both the pump and the fans were still only spinning at 20 percent of their maximum. Having a system that's so quiet under load is just divine. If you want to see how this hardline build performed at a full overclock, head over to our Build It feature, on page 68, for a full set of benchmarks.

Mmm, all those boxes!

COMPONENT JUSTIFICATION

OK, SO THIS ISN'T what you would call a cheap build—we made sure of that during the selection process. The idea was to piece together one of the world's gnarliest ITX systems we could, while still conforming to the NZXT Manta's aesthetic design styles.

With that in mind, there were only a few motherboards we could choose from. For us, the Asus Z170i Pro Gaming was the best choice. We stripped the heatsinks, sprayed the tops with Plasti Dip, leaving the sides stock to allow for good heat dissipation, and took advantage of that M.2 slot hidden on the underside of the motherboard.

Our next port of call was memory—16GB seems to be the norm nowadays, but we wanted to push the envelope on rendering performance, so we decided to double the average, and instead went with a pair of HyperX's Savage 16GB 2,666MT/s C15 sticks.

Next up was the processor, to match the Z170 board. The Core i7-6700K was a no-brainer, but instead of taking our chances with the silicon lottery, we opted to grab ourselves a pre-binned chip, capable of pushing 5GHz with liquid cooling—and, boy, was that worth it.

For the power supply unit, we went with a Corsair AX1200i. Overkill? Most certainly—we only expect to pull 580W from the wall at most. However, this selection was all about noise reduction. We wanted to ensure that, even under load and overclocked, the PSU was only drawing about 50 percent of its capacity from the wall. This way, the fan wouldn't run, and we would benefit from that reduced noise output.

Storage was tricky—we knew we needed to take advantage of that M.2 slot hidden under the board, so we chose Samsung's 950 Pro 512GB PCIe SSD, for the best possible read and write speeds. Being located on the back should help with cooling. For backup storage, we opted for a OCZ Trion 100 1TB SSD—affordable solid-state drive.

For the GPU, we ultimately settled on the Fury X. Being VR-ready, with 4GB of HBM for incredible memory bandwidth, and tasty FreeSync compatibility made it an easy decision. Couple that with the sexy single-slot GPU adapter EKWB provides and, hot damn, is she pretty!

BENCHMARKS

	Closed Loop	NZXT Kraken X61
CPU Idle Temperature – Stock	30 C	**21 C**
CPU Load Temperature – Stock	**48 C**	61 C
CPU Idle Temperature – Overclock @ 4.9GHz	32 C	**27 C**
CPU Load Temperature – Overclock @ 4.9GHz	**66 C**	86 C
Load Temp – Fire Strike	**47 C**	55 C
Rated Fan Noise – 50 Percent	**14.85dB(A)**	18.50dB(A)
Rated Fan Static Pressure – 50 Percent	**1.97mmH_2O**	0.98mmH_2O
Maximum Overclock Achieved	**5GHz**	4.9GHz

Best scores in bold. All benchmarks were performed utilizing their respected cooling methods for the duration of the benchmark, or a single instance of Prime 95 for five minutes. Both maximum overclocks achieved utilizing 1.41V on the CPU core, with the same chip, stability checked using OCCT's Linpack test.

CONCLUSION

SO, IS IT ALL WORTH IT? In our opinion, yes. There's no doubt that it's pricey, but the lower temperatures and overall noise reduction is fantastic. Couple that with such a sexy looking final system, and you're guaranteed to have a good time piecing one of these together. It's more of an ornament than a system, albeit an ornament capable of pushing your hardware to the absolute limits. The temperatures we achieved at the overclocks we did were nigh-on astronomical. Of course, it wasn't as straightforward as a standard build, and there's a lot to take into consideration, whether that's what fittings you're utilizing, or what angles you need to bend, and where to route your cables, but in the end, in our opinion, at least, it was thoroughly worth it. We'll let the picture above speak for itself here.

MAGNETIC LEVITATION COOLING FANS: TAKING TOMORROW OUT FOR A SPIN

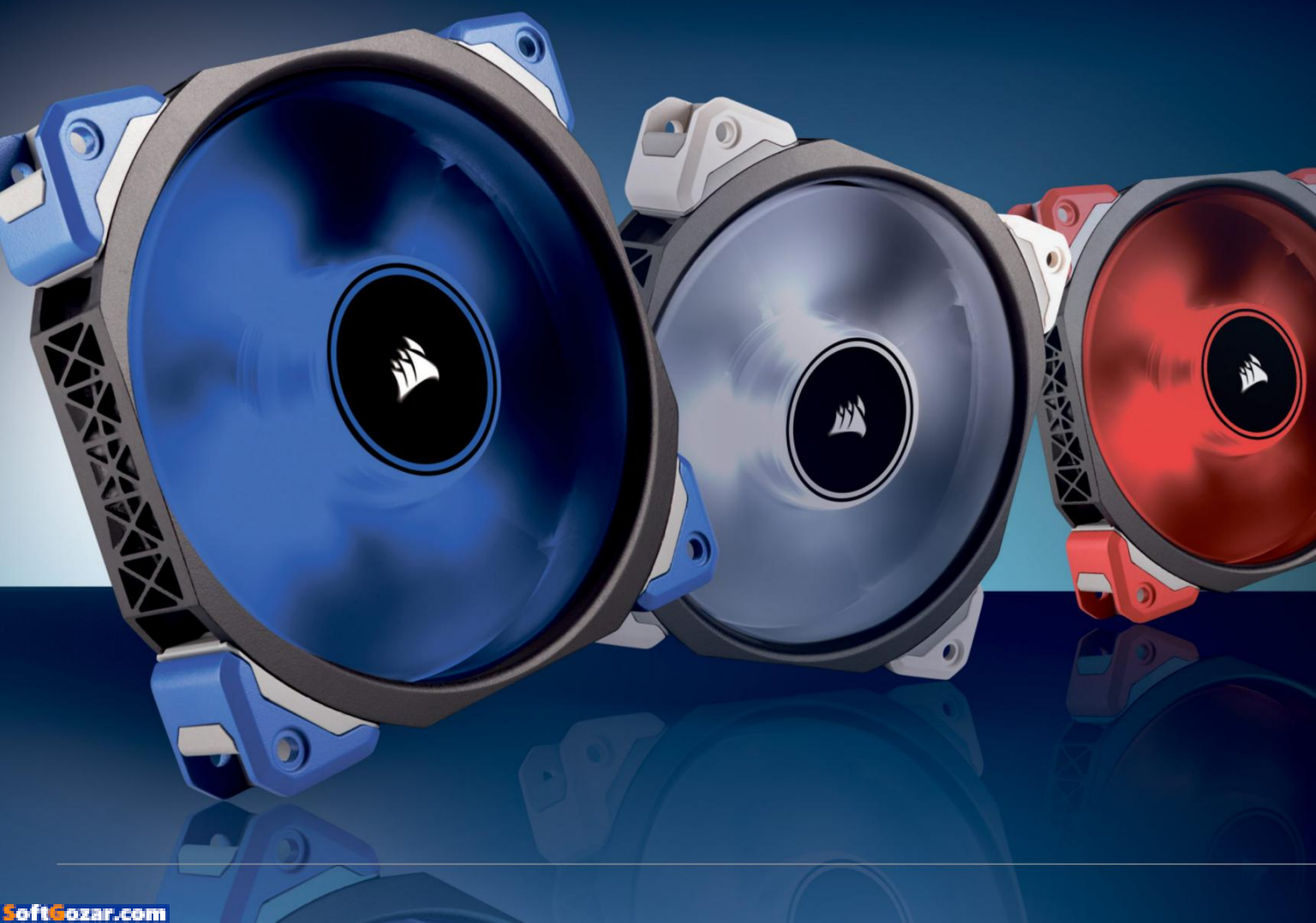
Hoverboards aren't here yet, but Magnetic Levitation is the next best thing ready for your new rig

THE LOWLY COOLING FAN doesn't get half the credit it deserves. There's one on almost every serious piece of hardware, and that's a good thing. Without them, your pricey CPU, laptop, or graphics card would overheat and become a paperweight in a few short minutes.

The hotter the hardware, the harder it is keep cool and quiet: competing goals that aren't easy to satisfy simultaneously. Turn up the RPM and temperatures drop fast, but get ready for a racket; beyond 1200 RPM the noise from conventional fans goes from noticeable to noisome.

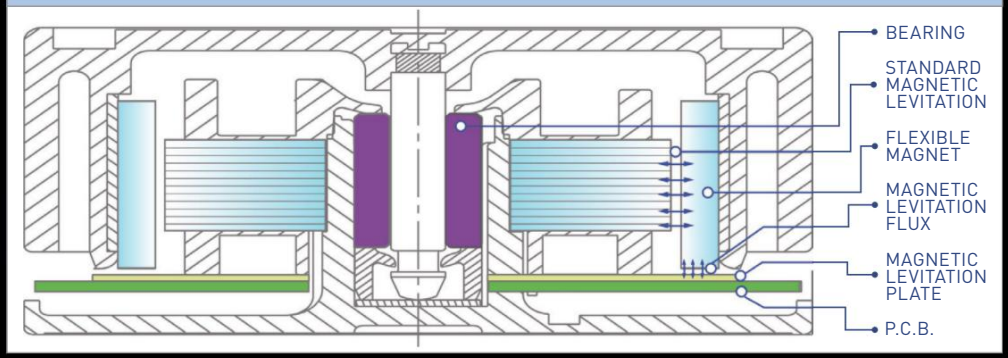
While most fans are judged by how much air they can move, measured in CFM (cubic feet per minute), there's another factor to consider. Cooling units frequently require fan installation against a radiator, heat sink, or dust screen. These obstructions slow air flow and require special fans with a high static pressure to overcome the resistance they introduce.

This means not all fans are created equal. Some are made for high-volume airflow into a case through low-pressure side panel grills, while others are made to push air through dense filters and metal vanes. Moreover, excellence in one area limits performance in others, so it pays to know your fans.



MAGNETIC LEVITATION DIAGRAM

By replacing conventional, friction-inducing fan hub components with a design that uses magnetic plates, Magnetic Levitation hubs promise next generation jumps in the speed and efficiency of cooling fan design.



MAGNETIC LEVITATION TOMORROW'S APPROACH

KEEPING IT QUIET while also staying chill is a tall order, and requires going beyond any off-the-shelf solutions available today. Corsair's new 120mm and 140mm ML lineup tackles these long-standing challenges with a series of fresh rotor designs that improve pressure and air flow, but the big innovation is in the hub, which holds a surprise that ditches current mechanical paradigms and takes a page from futuristic aerospace R&D.

All current consumer cooling fan technology is based on a handful of straightforward mechanical bearing designs. No matter how smooth or well made, traditional bearings are wear items that eventually fail. Moreover, each solution has plenty of quirks.

Ball bearing fans get noisy long before it's time to replace them, making their longer lifespans a double edged sword. The sleeved bearing designs used by most of the industry have a shorter duty cycle than pure bearing solutions and prefer vertical orientations, limiting where they can be used. That's the price of moving parts and friction, especially over time.

Instead of a purely mechanical solution, Corsair employs Magnetic Levitation technology in the hub of its new ML series fans, sidestepping friction and wear problems by partially suspending the rotor within a magnetic field. Because of reduced contact with other fan components, the newly designed, high-efficiency blades are free to move more quickly, quietly, and without the drag of mechanical driveline components draining power and shortening operating lifespan with every rotation.

That reduced friction also pays off with increased rotor speeds and lower decibel readings. For example, while most conventional designs top out loud and proud under 2000 RPM, ML120 series fans spin a full 20% faster, up to a heady 2400 RPM, and with subdued sound levels older designs can't touch. ML fans also wind down to 400 RPM for a quiet mode that lives up to its name, providing a vast RPM range to play with during test and tune sessions.

The result? Enough silence, fan speed, and static pressure on tap to keep up with virtually any application.

LOOKING GOOD MEANS MORE THAN MOVES

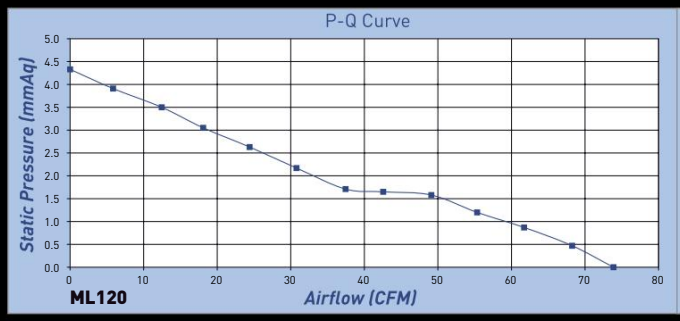
A PROPERLY SORTED RIG is about more than speed these days: fashion is also a factor. Cooling fans with plain blades and a box of screws won't cut it when you're pushing a build beyond brown-bag basics.

For a slick but subdued look, products like the ML Pro series come with a range of four colors for corner caps, matching most components and cases right out of the box without going gaudy. Even if stealthy sleeper systems are more your style you're still good to go since black is included. Beyond good looks, the caps' soft rubber design dampens vibrations before they touch the chassis, stopping secondary sound problems before they start.

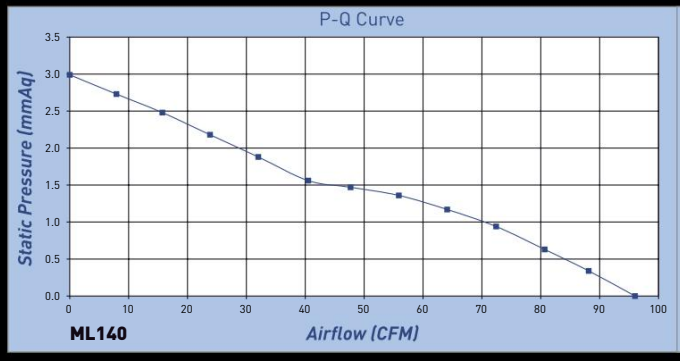
For more flash, the ML Pro LED series adds a quad-LED arrangement that diffuses hub-mounted light throughout the impeller with a layout bright enough to show through thick metal grills, braided cables, or dark Lucite panels.

When it's time to upgrade the fans on that CLC system or huge heat sink, remember that high static pressure fan kits provide the push needed for cooling thick radiators while retaining the options found in high airflow varieties. For Corsair, this means including Magnetic Levitation hubs, interchangeable corner color caps, and even a high static air pressure led-illuminated version.

Availability in both 120mm and 140mm sizes for all models provides a solution for every case and cooling scenario. Big or small, slick or subtle; no matter what build project you've got planned, the new wave of Magnetic Levitation fans, such as Corsair's ML series, have you covered. Find out more at **corsair.com/MLSeries**.



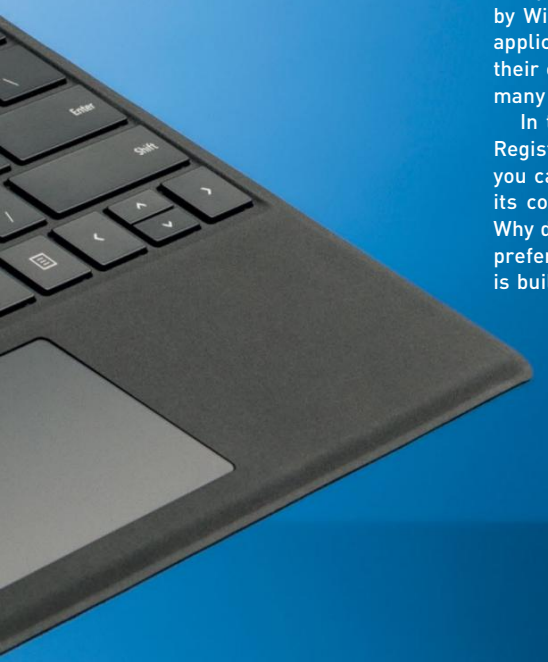
While popular, 120MM fans work hard to push air and make more noise than their bigger brothers. It takes a smooth design to produce high pressure, high RPM and quiet performance.



An extra 20MM may not seem like much but the numbers don't lie. With lower speeds and therefore less noise, the big blades push air much more easily. If your case has the space, go big when it comes to fan size.

MASTER THE WINDOWS 10 REGISTRY

Tweak your PC with the help of Regedit and *Nick Peers*

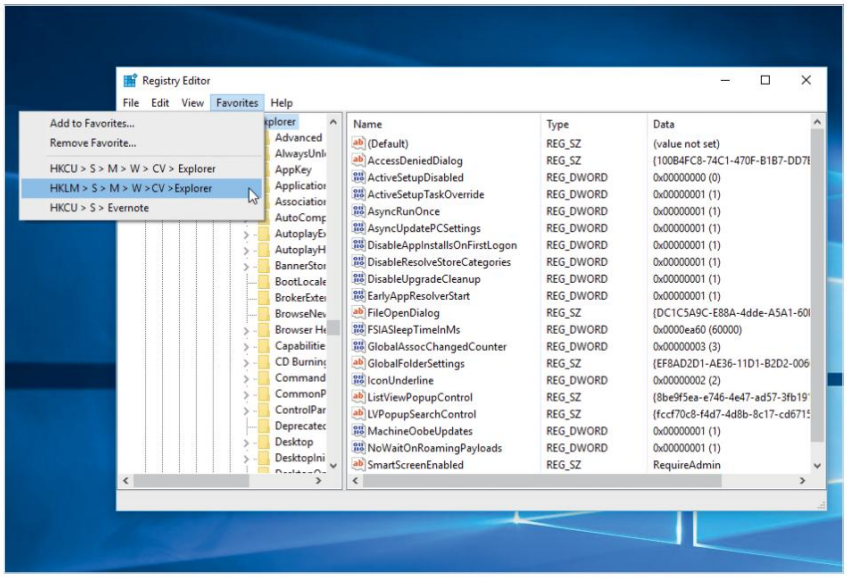


The Registry has been a vital component of Windows for the last 20-odd years. It's a central database, where all kinds of settings and preferences are stored, and not just by Windows, either. The vast majority of applications installed on your PC store their own data in the Registry, too, as do many hardware devices.

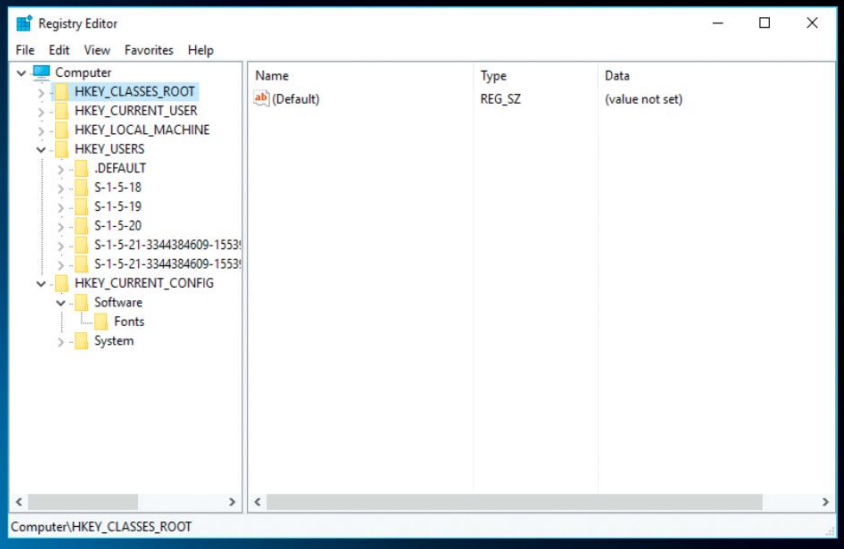
In this feature, we'll examine how the Registry is constructed, plus reveal how you can access its data—not just to view its contents, but also to tweak settings. Why do this? It all boils down to personal preference, and the fact that Windows is built with a wide range of hardware in mind, so many settings are configured to just work, rather than push your PC's performance, or give you granular control over various aspects of how it works.

The Registry is also a useful beast for those unhappy with how Windows 10 looks and operates—that's because lurking behind some of the less appealing parts of the new user interface are settings you can tweak that restore classic functionality. We'll examine some of these tweaks in this feature. We'll also reveal a number of tweaks that may help you boost your gaming performance, too, plus how you can use the Registry to tweak various security and privacy settings that are normally reserved for Windows 10 Professional users.

All of this sounds frightfully (or delightfully) meddlesome, so it's a good idea to back up your Registry before you start to mess around—we'll reveal what you need to do (plus how to restore your backup if things go wrong). Finally, jumping around different parts of the Registry can be time-consuming, so we'll reveal how you can quickly build scripts using Notepad to change multiple parts of the Registry with relative ease.



It's a good idea to create quick links to frequently accessed keys.



What Goes Where?

The Registry is divided into five main keys or "hives"—here's what goes where.

HKEY_CLASSES_ROOT: This is where file extension association information is stored, with individual sub-keys for each file type. It basically tells Windows what to do when you open or view anything, from a specific file to a drive on your PC.

HKEY_CURRENT_USER: This contains per-user settings and options, for Windows and applications. It's actually an alias that points to your user's sub-key that's stored under HKEY_USERS, which is created when you log on to Windows. Note you can still edit its contents, but you're effectively editing the contents of the HKEY_USERS sub-key.

HKEY_LOCAL_MACHINE: This is where most application and Windows settings can be found, and corresponds to preferences and options that apply to all users. If a program is installed for all users, its data is stored here; if it's installed for just one user, then its settings are instead found under HKEY_CURRENT_USER.

HKEY_USERS: This is the actual location of all individual user settings and options. Each sub-key corresponds to a user profile's security ID, which begins "S-1-5-xx."

HKEY_CURRENT_CONFIG: This is another alias. This key points to the HKEY_LOCAL_MACHINE → SYSTEM → CurrentControlSet → CurrentControlSet → Hardware Profiles → Current key, which stores information about the current hardware profile in use. It's basically a convenient shortcut to these settings.

Let's open with a bit of Registry 101. The Registry is made up of a group of files called "hives," which are stored in two separate folders on your hard drive: "Windows → System32 → Config" for system-wide settings, and your personal User folder for settings associated specifically with your user account.

Each hive consists of a different set of preferences and configuration data—for example, the system-wide software settings are stored in a file called SOFTWARE. This information is organized into sub-folders known as "keys." Each key contains one or more "values" with their associated "value data," which are the actual configuration settings for your PC.

There are numerous types of value, depending on the data they contain. The most common include REG_DWORD values, which contain binary or hexadecimal numbers in 32-bit format (the 64-bit equivalent is REG_QWORD), and REG_SZ, which contains text-like drive labels, context menu options, or the path to a particular folder or file on your hard drive.

Whenever Windows, a program, or hardware device needs certain settings or information, it consults the Registry for the specific values it needs, enabling it to function correctly. These keys, sub-keys, and values are usually added when the software or hardware is first installed, and organized in such a way as to be accessible (many software and Windows settings are found inside the HKEY_CURRENT_USER > SOFTWARE key, for example).

Access and edit the Registry

The best tool for accessing the Registry is Registry Editor (regedit.exe). This is built into Windows, and has all the tools you need for editing the Registry. The quickest way to access it is by pressing Win-R, or typing "regedit"and hitting Enter, or you can open the Windows folder and create a shortcut to regedit.exe from there, for pinning wherever you want. Regedit naturally requires administrator access, so click "Yes" when prompted after launching it.

You'll see a two-paned window—in the left are the keys and sub-keys, while the right-hand window displays the values currently associated with the selected key. In terms of Windows and application settings, the best key to start looking inside is the HKEY_CURRENT_USER key. Double-click this, and you'll see its sub-keys appear. Double-click one of these, and its sub-keys will appear, and so on, and so forth. Select a key to see its associated values appear in the right-hand window.

Navigating the Registry can be a time-consuming process as you move between keys, sub-keys, and values. One way to

speed up access to frequently viewed sub-keys is to make use of Regedit's Favorites feature—select the key you want easy access to, and choose "Favorites → Add to Favorites." By default, the sub-key name is given as its entry—you might want to tweak this to make it easier to link (tip: use abbreviations like HKLM for HKEY_LOCAL_MACHINE to keep things relatively short), and click "OK." In future, jump back to the key by selecting it from the Favorites menu.

There are other useful shortcuts when navigating Registry Editor. For instance, open a key containing dozens of sub-keys, and you can quickly jump to one of these by typing the first two or three letters of its name. Or use the cursor keys to navigate around the Registry, using the left arrow to collapse previously opened sub-keys.

Tweak Windows 10

Many Registry tweaks can be performed outside of Registry Editor, simply by using Windows' own tools and dialog boxes—for example, choosing whether or not to show hidden files is best done from File Explorer's "Options" dialog (select the "View" tab). With this in mind, we're going to focus on tweaks you can't make using Windows' own tools.

Let's start by creating a Registry value that enables the hidden Dark Theme in Windows 10, which provides light text on a dark background for those who need it. This will change all widgets, menus, and apps such as Edge and Mail, and can easily be toggled on or off as required.

First, browse to the following key: HKEY_LOCAL_MACHINE → SOFTWARE → Microsoft → Windows → CurrentVersion → Themes → Personalize

If "Personalize" doesn't exist, right-click the "Themes" key, and choose "New → Key" to create it. Once done, select "Personalize" in the left-hand pane, then right-click on some blank space in the right-hand pane, and choose "New → DWORD (32-bit) Value." Name the value "AppsUseLightTheme," then double-click it, and verify its value is 0 (it should be by default). Next, you need to switch to the corresponding folder in the HKEY_CURRENT_USER branch—the swiftest way to do this is to right-click the "Personalize" key, and choose "Go to HKEY_CURRENT_USER." Once there, create "AppsUseLightTheme" there, too, again with a value of 0.

Conventional wisdom tells you to reboot your PC (or log off Windows) to enable most tweaks, but in this case, the change is immediate—just click "Start → Settings" to see the new theme in action. How do you undo this particular tweak? You have two options: one, simply delete both values you created, or you can double-click each one in turn, and change them to 1, enabling you to switch back and forth easily.

When you are expected to reboot, try simply restarting the Explorer process first. To do this, right-click "Task Manager," click "More details" if necessary, then scroll down to the bottom of the "Processes" tab, where you'll find "Explorer" in the "Windows Processes" section. Right-click "Explorer," and choose "Restart," and the tweak should—in most cases—be applied.

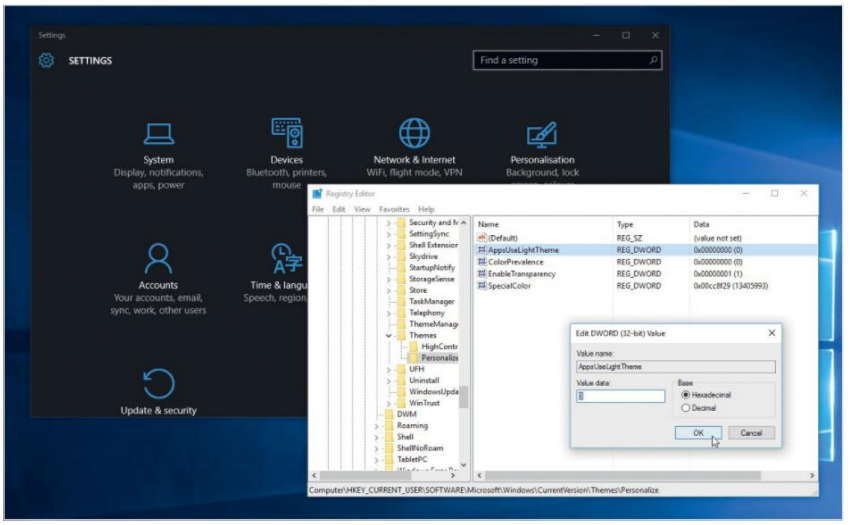
More great tweaks

The next tweak enables you to increase the transparency on the Taskbar. Go to HKLM (HKEY_LOCAL_MACHINE) → SOFTWARE → Microsoft → Windows → CurrentVersion → Advanced, and create a new DWORD (32-bit) Value called "UseOLEDTaskbarTransparency." Give it a value of 1, then select "Start → Settings → Personalization → Colors," and flick the "Make Start, taskbar, and Action Center transparent" switch on (or off and on again if it's already enabled) to see the tweak in action. Again, changing the value to 0, or deleting the value, will remove the tweak.

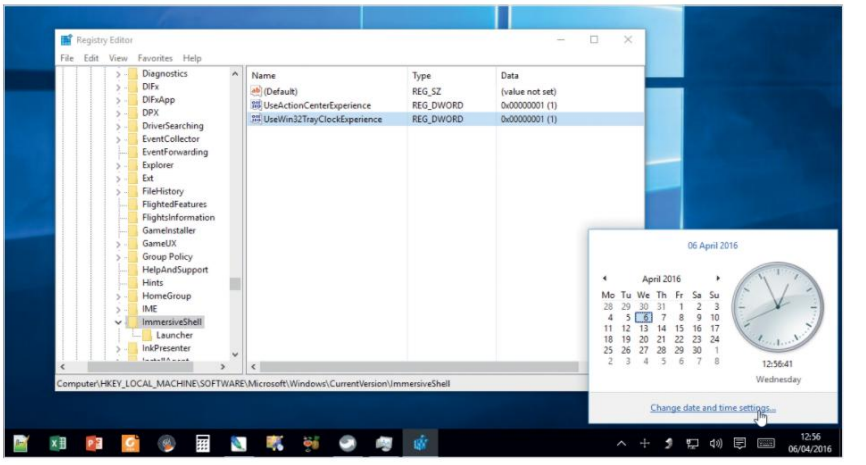
The next three tweaks enable you to restore various Taskbar notification area user interfaces from Windows 7 and 8.1. First, the volume control: Browse to HKLM → SOFTWARE → Microsoft → Windows NT → CurrentVersion, then create a key called "MTCUVC" under "CurrentVersion." From here, create a new DWORD value called "EnableMtcUvc," and set its value to 0.

To restore the Windows 7 classic UI for both Date and Time, and Battery, browse to HKLM → SOFTWARE → Microsoft → Windows → CurrentVersion → ImmersiveShell. Restore the UIs by creating two DWORD values called "UseWin32TrayClockExperience" and "UseWin32BatteryFlyout" respectively, then set their values to 1.

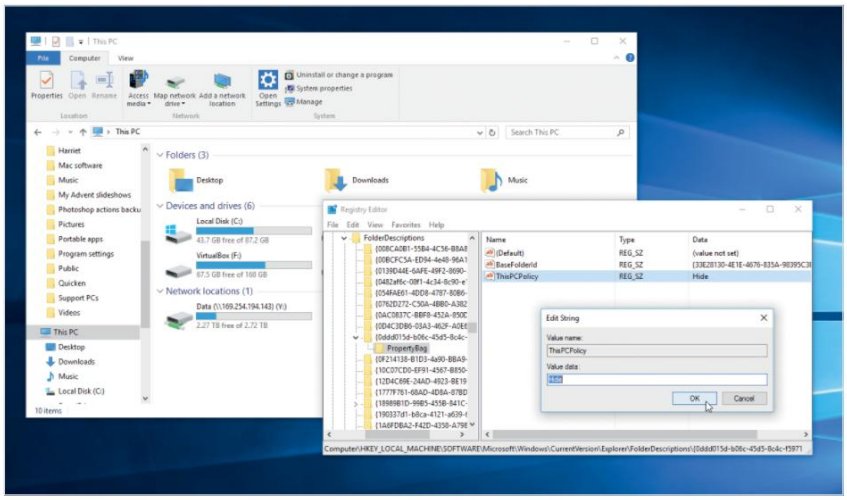
Don't like the way Windows has removed balloon notifications in favor of slide-in "toasts"? Go to HKCU (HKEY_CURRENT_USER) → SOFTWARE → Policies → Microsoft → Windows →



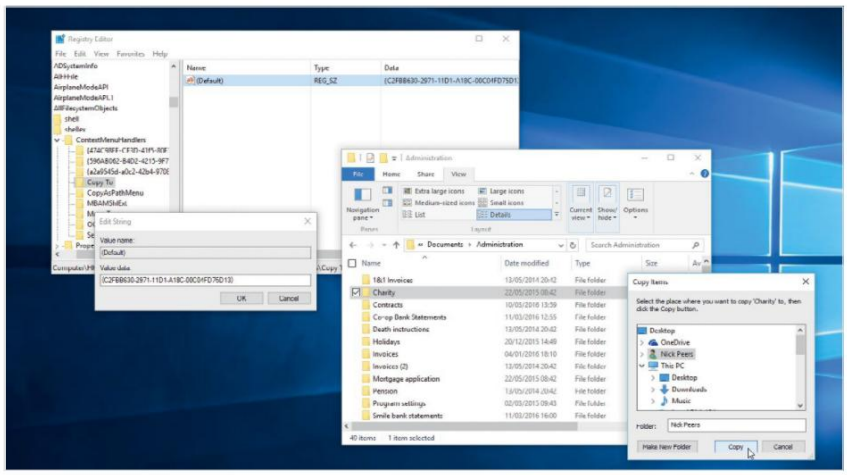
This relatively simple tweak enables a hidden theme.



You can restore familiar UIs for Taskbar notification area icons.



Streamline the "This PC" folder view by removing unused folders.



You can customize right-click menus through the Registry.

Explorer, create a new DWORD value called "EnableLegacyBalloonNotifications" and give it a value of 1.

Want to hide selected user folders from view when browsing "This PC"? Browse to HKLM → SOFTWARE → Microsoft → Windows → CurrentVersion → Explorer → FolderDescriptions. You'll see a string of strangely named keys, each pointing to a different shell folder. Restrict your search to those keys with ">" next to them, indicating they have sub-keys. Select each one in turn, and use the "Name" value to help identify them as Local Pictures, Desktop, Documents, Downloads, Music, and Videos folders—the "Local" reference confirms they're your personal user folders. Expand the key and select the "PropertyBag" key inside it. You'll see a REG_SZ value called "ThisPCPolicy" in the right-hand pane. Double-click this and change it from "Show" to "Hide." This will hide the folder in "This PC" view after you've restarted Explorer.

Add options to context menu

Save time moving and copying files by adding two options to the context menu that appears when you right-click a file or folder. Browse to HKEY_CLASSES_ROOT → AllFilesystemObjects → Shellex → ContextMenuHandlers, then create two sub-keys beneath this called "Move To" and "Copy To" respectively. Select the "Move To" key, then double-click the "(Default)" value and change it to: {C2FBB631-2971-11D1-A18C-00C04FD75D13}. Now double-click "(Default)" under the "Copy To" key, and change it to: {C2FBB630-2971-11D1-A18C-00C04FD75D13}. The change is

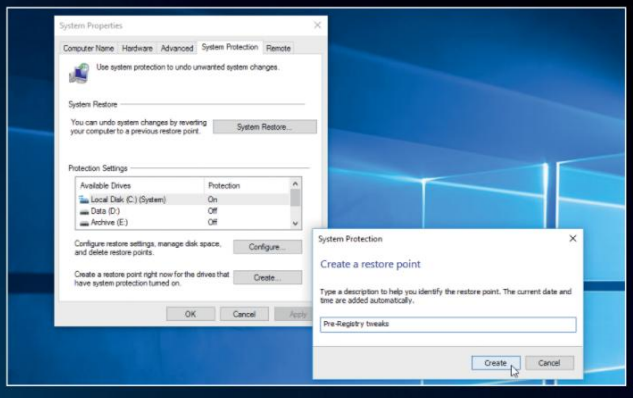
Back Up the Registry

Before you start tweaking the Registry, ask yourself what you'll do if something goes wrong. Most tweaks won't bring your system grinding to a halt, but they may render applications unusable, or result in strange behavior you weren't expecting. Some Registry edits are easier to undo than others as well—so make things easier for yourself (and your health) by following a multi-layered approach to taking precautions.

Before you begin, take a System Restore point, which backs up the Registry in its current state, as well as other system files. Type "system protection" into the Cortana search box, and select "Create a restore point." Verify System Restore is switched on for your system drive (click "Configure..." if it's not), then click "Create." Give your Restore point a suitable name, such as "Pre-Registry tweaks," and click "Create" again.

This is your fall-back backup. If all else goes wrong, you can access System Restore from within Windows itself (click "System Restore..." from the "Create a Restore point" screen), or from the list of recovery options if Windows won't boot—choose "Troubleshoot," then "Advanced," and "System Restore" to select the Restore point you created earlier.

It's also a good idea to back up individual Registry keys before you start changing



Take a fail-safe backup of your Registry before editing it.

them—this is done from within Registry Editor. Right-click the target key in the left-hand pane, and choose "Export." Again, give your backup a suitable name (and save it to your backup drive) before clicking "Save." Backed-up settings are stored in the .reg format—you can restore them via "File → Import" inside Registry Editor, or simply by double-clicking the file and clicking "Yes" twice. These settings will overwrite your changes, restoring things to how they were.

immediate—right-click a file or folder in File Explorer to see the options appear.

The following tweak makes it easy to open files in Notepad to view and edit. Browse to HKEY_CLASSES ROOT → * → Shell. Create a new sub-key called "Open with Notepad," and create another sub-key inside that called "command." With "command" selected, double-click "(Default)," and change its value to "notepad.exe %1." If you have another text editor installed in your Program Files folder, you can use that instead—for example, "notepad++.exe." Change the "Open with..." sub-key's name to suit—it's what's displayed on the context menu when you right-click a file.

Boost performance

Registry tweaks aren't just about wresting back control over the interface—dig deeply, and you can even make certain aspects of Windows run faster, too. And we're not just talking about visual tricks, such as making menu entries appear quicker (although if you'd like to do that, navigate to HKCU → Control Panel → Desktop, and experiment with the "MenuShowDelay" value—try a setting of 20, and reboot to feel the effects).

Windows 10 has a built-in delay before it starts loading programs from the Startup folder, to give itself time to load. If you're running Windows on a fast PC, you can try eliminating the delay to see if it speeds up the overall startup time. Navigate to HKCU → SOFTWARE → Microsoft → Windows → CurrentVersion → Explorer. Create a new sub-key called "Serialize," then create a new DWORD value inside "Serialize" called "StartupDelayInMSec." Leave its value set at 0, reboot, and see if it makes a difference (remove it if it slows things down).

The following tweaks may help speed up your gaming performance. The first may reduce latency and ping in some games. Browse to HKLM → SYSTEM → CurrentControlSet → Services → Tcpip → Parameters → Interfaces. You'll see a list of keys relating to different network interfaces—identify your Wi-Fi or Ethernet adapter from the IPAddress value, then create three new DWORD values: "TcpAckFrequency," "TCPNoDelay," and "TcpDelAckTicks." Set the first two to 1, and leave the last one at 0.

Next, try disabling network throttling. Browse to HKLM → SOFTWARE → Microsoft → Windows NT → CurrentVersion → Multimedia → SystemProfile. Double-click or create a new DWORD called "NetworkThrottlingIndex," and set its Hexadecimal value to ffffffff. While here, edit (or create) the "SystemResponsiveness" DWORD value, but set this to 00000000 for maximum streaming.

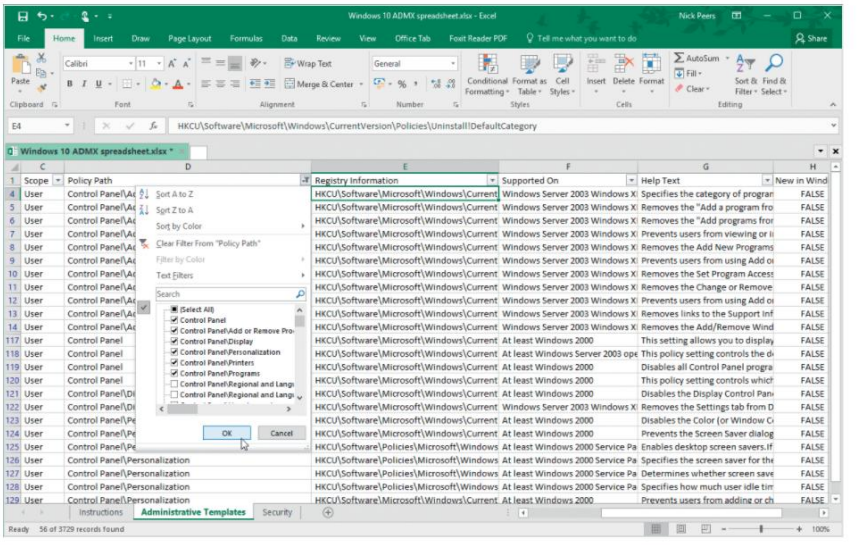
Browse from here to the Tasks → Games sub-key. Verify "GPU Priority" is set to 8, and change the Priority value to 6, which will throw more system resources at games.

Find more tweaks

You'll find the Internet is littered with Registry tweaks for you to try, but always take precautions before you follow any—see the box on backing up. Tweaks from older versions of Windows (particularly Windows 8 and 8.1) should also work in Windows 10, but it's not always guaranteed.

When surfing the net for useful tweaks—particularly when it comes to securing your PC—you'll often find a reference to gpedit.msc, or Group Policy Editor. This handy tool makes it easy to set various security and privacy policies in Windows, and while it's aimed at enterprise and business users, it's often handy for us mere mortals, too.

The only problem with gpedit.msc is that it's not available in Home editions of Windows. But don't worry, because Group Policy Editor is a neat front end for various Registry settings—all you need to know is which tweak applies to which Registry setting, and thanks to a handy Excel file from Microsoft, you can do just that. Download the Windows 10 ADMX spreadsheet.xlsx file from www.microsoft.com/en-us/download/details.aspx?id=25250 for the translation you need.



Who needs gpedit.msc when you have the Registry?

Build Registry Scripts

Why get your hands messy with Registry Editor when you can make changes to the Registry directly from Notepad? By creating special script files using any text editor, then saving them with a .reg file extension, you simply have to double-click the .reg file to merge your changes into the Registry.

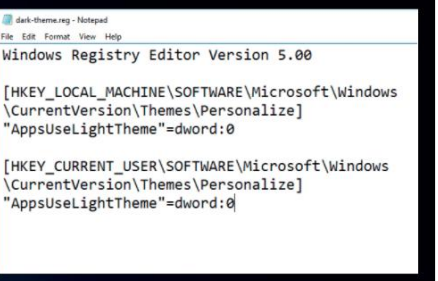
To do this, open a blank document in Notepad. Type the following line at the top:
Windows Registry Editor Version 5.00

This identifies the script as a Registry file. Add a blank line beneath this, then type below that:
[Regpath]

Keep the square brackets, but replace Regpath with the Registry key you wish to edit (any sub-keys that don't already exist will be automatically created, so no need to manually create them in Regedit first). Beneath this, type each of the values you wish to create or modify on separate lines using the following syntax:
"ValueName"=Valuetype:Value

Ignore Valuetype if the value is a string; otherwise, enter "binary" for hexadecimal values, or "dword" for dword values.

You can edit multiple Registry keys within a single document—make sure to leave a blank line between each "[Regpath]" entry. The screenshot reveals how this works in practice. Once done, choose "File → Save," change "Save as type:" to "All Files," and remember to save your file with a .reg extension. Once done, back up, and then double-click the file to merge it into the Registry, or right-click it and choose "Edit" to make changes to it.



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THE BEST VR GAMES

Consumer VR has finally landed. Here are the best games out right now and coming soon

BY DAN GRILIOPOULOS

SO VIRTUAL REALITY IS FINALLY HERE. Well, it's on sale, at least. Waiting lists are pretty long too. Plenty of us won't have been able to afford the $600–800 for the headset, or in fact the cost of the computer upgrade you'll need to run it on your system.

Of course, we're only talking about the biggest, best applications here, running on the best hardware. That said, we'd heartily recommend any interested parties try out the headsets before buying—we're already seeing them used extensively for marketing stands in malls, and it's likely that some of the phone and computer retailers will have demo stations soon enough.

Even so, they're still expensive, especially when you factor in the cost of the computer hardware most people will need—a new Oculus Ready computer is around $1,000. It's plausible, therefore, that the much more limited PlayStation VR will be the most mainstream gear, given that the total cost of a PS4, controllers, and headset will be under $800. The biggest argument not to buy any VR headset quite yet, though, is that what's available right now are early models, which will be replaced in a year or two by better versions. Already, Sony's bosses have been talking publicly about releasing a PlayStation 4.5, ostensibly to run games on super-resolution 4K screens, but more likely to be bundled with a headset, camera, and controllers, and to enable better quality, more impressive VR simulations.

If you want to try out VR on the cheap, the easiest way is to get a Google Cardboard headset for your smartphone. They're normally for sale for under $20, have a wide range of apps available, and are a good starting point to see whether VR is for you.

We're at the start of a new industry here, where the sculptors are tentatively chipping away at their rock, trying to work out the best techniques, and see what form lies inside. It may take some time for them to make something like Michelangelo's David—but we'll be happy to marvel at their primitive hewings for a while yet.

Eve: Valkyrie

Among MMOs, which typically feature 100 levels of goblin-bashing, *Eve: Online* is unique. It's carved out a niche as *the* intragalactic war sim, featuring mammoth battles that destroy thousands of dollars of virtual spaceships. *Valkyrie* is a spaceship dogfighting sim, set in the *Eve* world. It's competitive multiplayer-focused, and players can level up their characters and spaceships, but it also comes with a single-player PvE mode, if that's too serious. It comes free with the Oculus Rift. CCP has developed another game in the same universe, *Gunjack*, which is exclusive to Samsung Gear VR.

Lucky's Tale

Free with the Oculus Rift, *Lucky's Tale* is a platform collect-'em-up. Lucky, a fox, has to rescue his friend Piggy, who's been captured by a hungry snake monster. He does this by pursuing the trail of coins his porcine friend has left behind. Despite being a familiar 3D platformer in the style of *Mario 64*, it's disconcerting to play. The game directs the camera so gently that you forget you can look around, and when you do, there's a detailed, colorful world to see.

Windlands

This first-person game has you exploring a collapsed world using a grappling hook, to try to discover its secrets. The world consists of broken islands floating in the sky, and has a bright, blocky *Minecraft* look to it, with defunct mechanical titans among the few surviving buildings. You can play the game normally, hunting out secrets and hidden sections, follow the story, or attempt speed runs and time trials. If you want a non-violent, relaxing experience, look no further.

Tilt Brush

Not strictly a game, but it's game-y, and is made by Google, which has been quiet about its own VR ambitions beyond Cardboard. It's a 3D image-creation package, using the Vive's controllers. What's exceptional is the way you step inside the painting, making it more like sculpture. It has many of the same controls as an image-editing package, except they sit on your weaker hand, while you paint with light on your stronger hand. It's utterly intuitive and produces beautiful results.

Chronos

A rare exclusive to the Oculus Rift, *Chronos* tracks a boy's quest to destroy the evil that's threatening his homeland. You must explore an ancient labyrinth, which opens just once a year; fail in your quest, and you must return a year later, wiser, more attuned to magic, but older. And you will fail.... *Chronos* is one of the few VR launch titles that seems like a full game, with an intriguing premise.

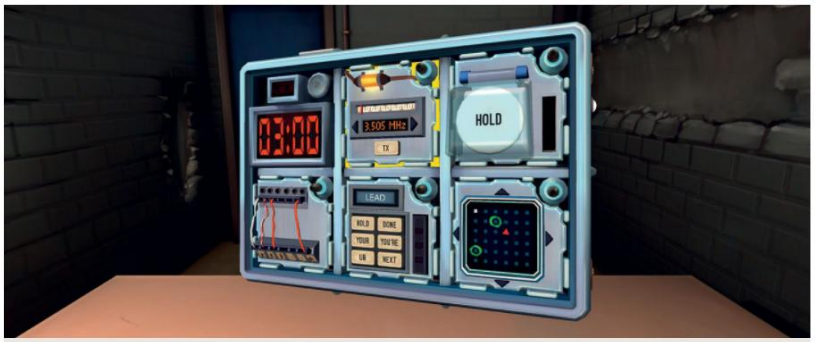
Fantastic Contraption

Exclusive to Vive, *Fantastic Contraption* is based on a 2008 game. In that game, players had to combine mechanical elements in a 2D structure to make a working machine that got a ball into a hole. With the Vive, you have to do it in 3D, on a floating island. So you can move all around the surreal bendy structures, and attempt to work out what's working and what's not, then move them with the controllers.

OUT NOW

ADR1FT

Almost an unofficial *Gravity: The Game*, this sim is set in a damaged space station floating above Earth. You play the part of an astronaut who wakes, amnesiac, in the ruins of the station, to find your oxygen running out. You have to explore the station to find the resources and tools to stay alive. Check out the full review on page 90.



Keep Talking and Nobody Explodes

A rare multiplayer VR game, *KTANE* is a weird mingling of tabletop aesthetics, roleplay, and the archaic joy of thumbing through a manual. One player wears the headset, and is presented with a bomb that is ludicrously over-engineered. He has to talk to other player(s), who are reading through a printed manual that explains the bomb's instructions—kind of. The challenge is to not get blown up, simple as that. A somewhat unusual but highly effective party game.

Audioshield

Dylan Fitterer is best known for his rhythm action game, *Audiosurf*, which turned any MP3 into a strange racing-stunt game. *Audioshield* shows he's not a one-trick pony by... extending the concept to VR. Seriously, though, *Audioshield* is pretty cool. You load up your MP3s and find yourself in a neon arena, with fireballs flying at you. They arrive in time to the music, and you must punch them out of the air on the beat. With your favorite tunes, it becomes a cross between dancing and boxing.

The Lab

There are so many spectacular sims for the Vive—such as *theBlu* or *Job Simulator*—that it's churlish to pick out just one, but Valve's bundle of samples is free and brilliant. It's a wide range of pocket ideas, ranging from a *Portal*-themed *Robot Repair* sim to a postcard mode, where you explore exotic locales.

Behind the Scenes of VR Development

Developing VR simulations is different from creating video games. For one thing, movement is very limited—so developers have to decide if they're going to use a trick, or not move the player at all. You need to shape your initial concept around that. Then you need to spend a lot of money on high-end PCs and the developer VR hardware.

Different player behavior also changes your design. "We had to consider that people spend less time maneuvering and more time inspecting the world," explained Dan Chambers, designer on *The Assembly*. "So we aimed for smaller environments with a richer level of detail. This is especially important given the challenges of motion sickness in VR."

You also need good environmental signposting to tell your story, as *The Assembly's* design manager, Steven Watts, points out. "Cut-scenes are impossible to implement in a traditional style, as taking control of the camera away from the player is prohibited, lest it induces simulator sickness." *The Assembly* uses audio cues, lighting, animation, and gaze detection to capture and direct the player's attention.

That detail isn't just visual; audio effects need to be accurate or the immersion is broken. For example, lifts in *The Assembly* have audio sources attached, so sound is realistically blocked and faded as they move. "On one hand, we have the benefit of positional audio technology," says Matt Simmonds, *The Assembly's* audio director, "but we also need to focus more on detail in sounds to make objects feel believable in a 3D space."

Finally, you have to make sure the humans are convincing. "We are most certainly not through the uncanny valley," says Martin Field, *The Assembly's* art manager. "If anything, VR emphasizes and amplifies any differences. Lip-synching and realistic animations are even more important in VR than for flat-screen games, as there's so much scope for spotting something that will break your immersion, and pull you out of the experience."

And these are the just the basics of producing a static, slow-paced VR investigation game—imagine what they're going to be like in a few years!

The Climb

Climbing is a fantastic form of exercise; it's both physical and mental, combining lifting your own body weight on your fingertips with route-finding and problem-solving. (In terms of 2D games, Bennett Foddy's *GIRP* is a great free simulation, if you don't like exercise.) It's also a solo, first-person experience—ideal for VR. It was a no-brainer, then, that someone would build a climbing sim in VR; the team behind it, however, is Crytek, the developer of the *Far Cry* and *Crysis* games, and creator of the CryEngine, so its game, *The Climb*, is rather handsome.

P.O.L.L.E.N.

A psychological adventure, *P.O.L.L.E.N.* is set in a deserted space station on the surface of Titan, in an alternate timeline where the Internet was never invented. You've been dispatched to work out what happened to the research team, who disappeared just ahead of the announcement of a remarkable discovery. It's a richly detailed, puzzling world, with a hint of terror—much like *Sunshine* or *Solaris*.

Edge of Nowhere

Most VR games are first-person, but Insomniac Games, creator of *Ratchet & Clank*, and *Spyro*, knows third-person best, and it's not changing that for VR. *Edge of Nowhere* is an action-adventure set in the Antarctic, where you have to find a missing expedition team lost in the mountains. It sounds like it draws on *Tomb Raider* and H.P. Lovecraft's *Mountains of Madness*—both of which are good things.

Rockband VR

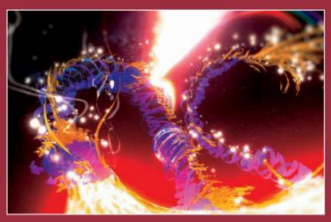
Guitar Hero was the first rock band game, but Harmonix perfected it with *Rock Band*, which was so good it almost killed the genre. *Rock Band VR* is the logical next step, where you play guitar in front of a huge crowd visible through the Oculus Rift.

Rigs: Mechanized Combat League

If there's one thing that the early VR title *Hawken* proved, it's that nothing looks better in VR than giant robots fighting. Sony seems to be taking that message to heart with *Rigs*, its giant robot fighting game. The aim is to "overload" your mech, and hurl yourself through a large mid-arena ring. To overload it, you need to collect power orbs, or attack the opposing team. At any point, you can switch modes to increase your damage, speed, or repair yourself. The resulting game is as high-energy as *Rocket League*, and only lasts 10 minutes a match.

The Best Cardboard Apps

TILT BRUSH GALLERY
On the opening pages, we talked about *Tilt Brush*, the bizarrely good Google Art package for the HTC Vive. Well, even if you don't have one, you can look at the images in *Tilt Brush Gallery*, and marvel at their neon weirdness.



INMIND VR
Although it pretends to be a scientific experiment, *InMind VR* is a rollercoaster ride through an environment that looks like we imagine the human mind to look. A much higher-res version is available on Vive and Oculus.

NYT VR
This app has a simple remit: to share the *New York Times* video content in virtual reality. It has well produced, smart content, ranging from journalism to documentaries. The firm aims to post new stories every month.

VRSE
Like the *New York Times* app, *Vrse* is an app about storytelling, that works with partner media including Vice, Apple, the UN, and the *New York Times*. It has a wide variety of 360-degree videos to watch.

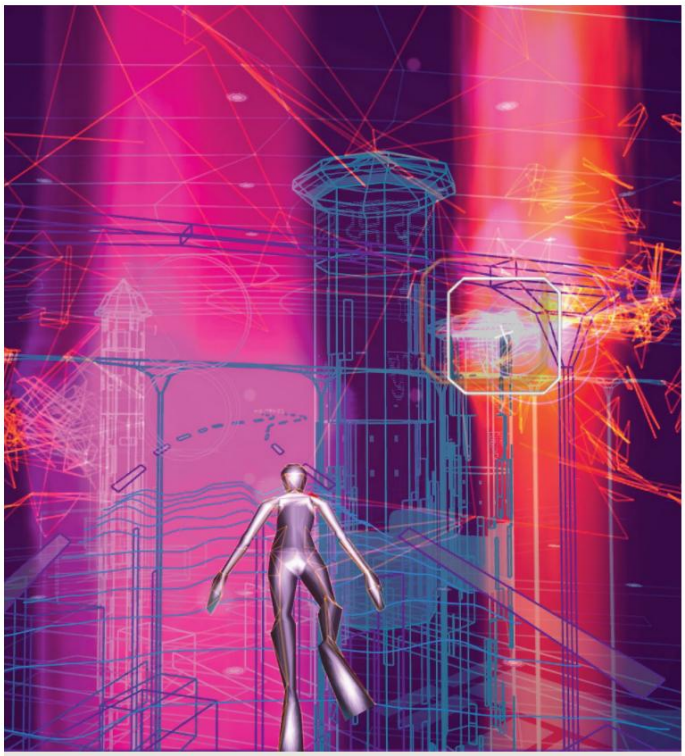
CARDBOARD DESIGN LAB
From Google, this is targeted at VR creators—which could soon include you. It talks about the best ways to design for VR, and the physiological, psychological, and ergonomic elements you need to take account of.

GOOGLE CARDBOARD CAMERA
Most video and photos for VR have so far been taken with bespoke equipment—but Google's smart tech has produced this, which can stitch together images, and record the sound of the environment, too.

YOUTUBE 360
This isn't a special app—YouTube updated in March 2015 to allow 360-degree videos. A quick search throws up hundreds of them, which can be experienced with a cheap Cardboard headset.

Minecraft VR

Since Markus "Notch" Persson sold his game to Microsoft, it has reversed his decision not to bring it to VR. The game will come to Microsoft's own Hololens Augmented Reality system, and to Oculus Rift and the Samsung Gear VR. For those who haven't played it, *Minecraft* is an open world exploration and crafting sandbox. You and your friends can go anywhere, build anything, and teleport to other dimensions, in a near-infinite procedurally generated world.



Rez Infinite

Tetsuya Mizuguchi's game *Rez* was first released in 2001, and swiftly became a cult classic. It was a trippy, always moving, shooting game, that looked like a Japanese *Tron*, and was paired with a classic electronica soundtrack. Part music video, part art installation, part game, *Rez* was unique. Now Mizuguchi is remaking it in VR, for a new generation of more open-minded gamers. He says that this version is the "futuristic synesthesia experience" he's always wanted to make. Vivid colors, weird effects, and enemies swirling around your humanoid avatar, and all of it in time to the music.

Giant Cop

The best jokes often make the best game ideas. We guess this one may have involved something to do with the "long arm of the law." You take control of a leviathan police officer, looming over a small seaside town, on your first day on the job. Your job is to arrest baddies from your high vantage, as Micro City's only line of defense. However, you're not only trying to catch baddies; your behavior acts as a moral compass for the other citizens, too. How you behave determines how they behave—whether that's softly and leniently, or harshly.

COMING SOON

The Assembly

nDreams isn't known for its VR games—it started as a Facebook and PlayStation home developer—but it has pivoted to work solely on VR games, and *The Assembly* is its first. It's a Ballardian dystopia of a game, set in a secret research facility, where the player takes on two roles—a new recruit and a senior professor, scared of the implications of their work. You explore this facility in first-person, following the story and solving puzzles to progress. It's an extremely detailed world, and is aiming to launch on Oculus Rift and PlayStation VR.

The Others

There's a ton of interesting-sounding titles coming to virtual reality, both from indie developers and big publishers. ***Star Wars Battlefront, Assassin's Creed VR, Eagle's Cry, Star Wars: Trials on Tatooine, Ark: Survival Evolved, Affected, Surgeon Simulator 2013***, and many more are due out soon.

Best Desktop Non-Game VR

VR DESKTOP
Pretty much essential. This is a simple app that reprojects your desktop into VR, on a curved plane around you. It makes launching other VR apps easier, and lets you do indulgent things like watch Netflix, other streaming media, or non-VR games, or run software with ease.

MYDREAM SWIFT
Where VR Desktop projects apps and movies on to a curve, Swift attempts to turn them into VR apps completely. It's not very well documented at the moment, but it produces mostly impressive results, and can be set up to automatically load on most apps.

ALTSPACE VR
A free app focused on making VR social. Like the earliest bits of most platforms, it's basically a glorified chatroom, but one that lets you hang out with people anywhere in the world, play games, and share content. It's that cyberpunk dream of the Internet come true.

THE FOO SHOW
This is a weird one. The Foo Show is a talk show hosted inside VR, where you're sitting right in the middle of the action, watching lo-fi avatars talk. The first episode features an interview with the developers of the superb *Firewatch*—taking place inside the game itself.

WEVR TRANSPORT
Not much to show just yet, but this has raised $25 million, and aims to be the YouTube of VR, providing frictionless publishing and distribution of curated VR movies and minimally interactive experiences. Majestic underwater sim *theBlu* is one of its projects.

TECH PORN

1 Headset

The Vive headset boasts a pair of 1080x1200 displays operating at 90Hz, viewed through fresnel lenses. This specification is the same as the Oculus Rift. Where the Vive has the edge, though, is the higher accuracy of its positional tracking system (using the base stations), which helps counter motion sickness. The front-facing camera helps you navigate obstacles in your room, as well.

2 Wireless controllers

The Oculus Rift ships with a standard Xbox One controller, which is a fine device, but it can't compete with the Vive's controllers. This is particularly important because the HTC Vive is designed for room-scale VR—having a controller in each hand really helps with immersion here. Rechargeable batteries mean you're not fighting with wires, and they last for over four hours, too.

HTC Vive

VIRTUAL REALITY has finally arrived, with both the Oculus Rift and HTC Vive available for pre-orders for those willing to live on the virtual bleeding edge. The Vive, spawned from a partnership between HTC and Valve, has the earlier lead, thanks to a more immersive experience. Termed "room-scale" VR, it uses a pair of base stations to track where you are in your room—enabling you to walk around your virtual worlds, instead of being stuck in front of your PC (although that works just fine, as well).

The other feature that's giving the Vive the edge at the moment is on the controller front. The pair of controllers is designed for use in virtual worlds, which is key when you have the freedom to wander. And while you're wandering, the inclusion of a camera on the front of the headset ensures that you don't catch yourself on that coffee table that you probably should have moved.

Unlike the Oculus Rift, the HTC Vive doesn't feature built-in audio (a pair of cheap and nasty earbuds are included, but they're best ignored). The cabling isn't ideal either—especially when you are on the move. It's still early days for the modern take on VR, but as we all know, competition helps push things forward. Indeed, at a recent VR event, we were told that there are over 40 headsets in development. Right now, though, the Vive is the one to beat.

–ALAN DEXTER

3 Base stations

The two "Lighthouse" base stations sync with the main unit to monitor your movements in the real world, so they can be translated into the virtual world. These connect with the main unit wirelessly, although they do need power to operate, which can limit where they go, depending on the layout of your room. They're easy to set up, though, and are unobtrusive.

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HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

WINDOWS TIP OF THE MONTH

STABILITY TESTING

Testing the stability of an overclock can be tricky. CineBench R15 is too short to be a reliable test, and Prime95 is too aggressive to be considered a real-world scenario. Our new favorite is OCCT (www.ocbase.com). If error-hunting or stability-checking, download this free app, click "CPU: linpack," select all logical processors (for those with Hyper-Threading), and hit "Run." It's a brutal synthetic test that ramps up and down, while testing memory over a prolonged period.

MAKE – USE – CREATE

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Hack Minecraft: Pi Edition and make a trebuchet

64
Play Xbox One and PlayStation 4 games on your PC

68
Build your own miniature, water-cooled dream PC

ZAK STOREY
STAFF WRITER

SELECTING STORAGE

I guarantee you that 95 percent of the questions I get asked are related to storage. How much RAM do I need? What should I store my games on? Are PCIe drives that much faster? The list goes ever onward—and rightly so, because it's an especially troublesome question to nail.

The most common argument I see online right now revolves around PCIe storage. In particular, that there's simply no point in making that jump. After all, what's the real difference between an eight-second boot time and a four-second boot time? It's just not worth the money, surely? While, in many respects, those boot times do prove that point, you have to realize that storage affects far more than that. Ever copied a folder across to a new SSD, or moved video from one place on your hard drive to another? What about rendering a video file to your desktop? In almost every scenario, PCIe storage is quicker than its SATA 3 cousins. And that's what I mean—it's not just about boot times.

That said, if you're after the best bang for your buck, I wouldn't advocate storing everything on a PCIe drive. Games, for instance, although benefitting from SSD storage speeds, tend not to gain much in the way of faster load times by being placed on RAID 0 arrays or PCIe storage. Save yourself some moolah, and get yourself a high-capacity, cheap SSD to put the rest of your gaming library on.

↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

There you have it, folks—the glory of the Rift, stripped bare.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

Oculus Rift CV1

Be warned—these super-delicate cables can be tricky to handle.

These snazzy UV LEDs let the IR sensor know which way you're facing.

BACKGROUND:

We've had our eyes on Oculus since the beginning, having dismantled (and re-mantled) both development versions of its VR headset. But, today, we've got the real deal: the consumer-ready, OMG-it's-finally-here Oculus Rift. After four long years of development, what's changed? What's stayed the same? And can we put it down long enough to take it apart and find out? Grab your tools and join us at the teardown table, because the future is now—we're deconstructing the Oculus Rift.

MAJOR TECH SPECS:

- Dual OLED displays with a combined resolution of 2160x1200
- 90fps refresh rate
- Accelerometer, gyroscope, and magnetometer
- 360-degree headset tracking via Constellation IR camera
- Horizontal field of view greater than 100 degrees

KEY FINDINGS:

- This is the sleekest Rift yet—lightweight, impressively comfortable, and now with earphones built in for maximum immersion. A thick foam frame attempts to minimize the effects of "Oculus Face". It's simply attached with clips. Fewer screws means less weight!
- Removing the adjustable earphones couldn't be easier. An embedded flathead barrel nut secures the speaker arm, and spring contacts connect it to the wires in the headband. We've seen our share of expensive, unrepairable, nigh-on-impossible-to-disassemble earphones, so this is welcome.
- Stretchy black Lycra surrounds the lenses, covering a thin plastic frame. This dustproof fabric protects the Oculus's innards, while allowing the adjustable lenses some freedom to move. But how to remove it? We're stumped—until our teardown engineer finds the hidden interior clips that secure the frame. After a few flicks of the spudger, it's free.
- Separating the lens assembly reveals the custom, non-Note, larger-than-lens-aperture display. These OLEDs measure 90mm apiece, for a resulting pixel density of around 456ppi. What was behind those lenses and dual displays? A super-sleek, spring-loaded, dual rack-and-pinion mechanism for adjusting the spacing between the display/lens assemblies. Next to come out is the LED driver board, featuring all the labels a teardowner/reassemblist could want.
- Repairability Score: 7 out of 10 (10 is best). Cable management is much improved from the development kits, with a sturdy connector for easy removal. The earpiece speakers are easily removed, thanks to spring connectors. The face pad is held in with plastic clips, and pulls out easily. Getting inside is difficult, with hidden internal clips securing the dust shield. Replacing the head strap is impossible without cutting through the fabric on the headset. Intricate design and delicate ribbon cables make it very difficult to remove the lenses, displays, and motherboard.

Hack Minecraft Pi & Make a Trebuchet

YOU'LL NEED THIS

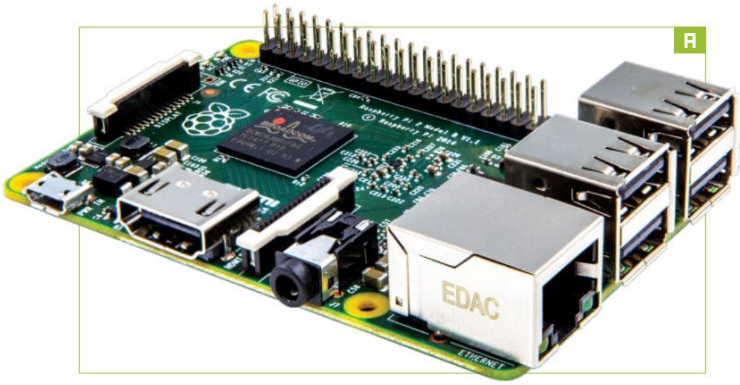
RASPBERRY Pi 2
The brilliant mini-computer costs under $45. See www.raspberrypi.org.

MINECRAFT
Download the latest version from http://pi.minecraft.net

ARGUABLY MORE FUN THAN the generously provided Wolfram Mathematica: Pi Edition is Mojang's generously provided *Minecraft: Pi Edition*. The latter is a cut-down version of the popular *Pocket Edition* and, as such, lacks life-threatening gameplay, but it does include more blocks than you can shake a stick at, and three types of saplings from which said sticks can be harvested.

This means that there's plenty of stuff with which to unleash your creativity, then, but all that clicking is hard work, and by dint of the edition including an elegant Python API, you can bring to fruition blocky versions of your wildest dreams with just a few lines of code.

Assuming you've got your Pi [**Image A**] up and running, download the latest version from http://pi.minecraft.net to your home directory. The authors stipulate the use of Raspbian, so that's what we recommend—your mileage may vary with other distros. **–JONNI BIDWELL**



1 GET STARTED

Minecraft requires the X server to be running, so if you're a boot-to-console type, you'll have to "startx." Start LXTerminal, and extract and run the contents of the archive, like so:

```
$ tar -xvzf minecraft-pi-0.1.1.tar.gz
$ cd mcpi
$ ./minecraft-pi
```

›› See how smoothly it runs? Toward the top-left corner, you can see your x, y, and z co-ordinates, which will change as you navigate the block-tastic environment. The x and z axes run parallel to the floor, whereas the y dimension denotes altitude. Each block (or voxel, to use the correct parlance) that makes up the landscape is described by integer co-ordinates and a BlockType. The "floor" doesn't really have any depth, so is, instead, said to be made of tiles. Empty space has the BlockType AIR, and there are about 90 other more tangible substances, including such delights as GLOWING_OBSIDIAN and TNT [**Image B**]. Your player's co-ordinates, in contrast to those of the blocks, have a decimal part, since you're able to move continuously within AIR blocks.

›› The API enables you to connect to a running *Minecraft* instance, and manipulate the player and terrain as befits your megalomaniacal tendencies. In order to service these, our first task is to copy the provided library, so that we don't mess with the vanilla installation of *Minecraft*. We'll make a special folder for all our mess called "~/picraft," and put all the API stuff in "~/picraft/minecraft." Open LXTerminal and issue the following directives:

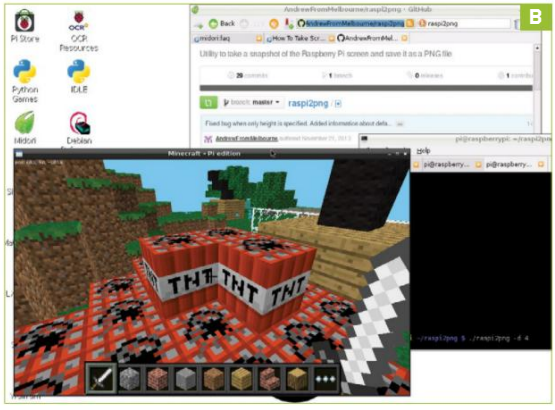
```
$ mkdir ~/picraft
$ cp -r ~/mcpi/api/python/mcpi ~/picraft/minecraft
```

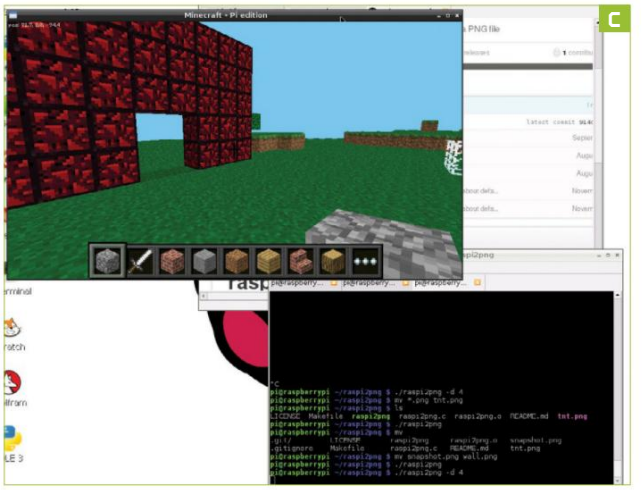
2 MOD MINECRAFT

Now, without further ado, let's make our first *Minecraft* modifications. We'll start by running an interactive Python session alongside *Minecraft*. So, open up another tab in LXTerminal, start *Minecraft*, and enter a world, then Alt-Tab back to the terminal, and open up Python in the other tab. Do the following in the Python tab:

```
import minecraft.minecraft as minecraft
import minecraft.block as block
mc = minecraft.Minecraft.create()
posVec = mc.player.getTilePos()
x = posVec.x
y = posVec.y
z = posVec.z
mc.postToChat(str(x)+' '+ str(y) +' '+ str(z))
```

›› Behold, our location is emblazoned on the screen for a few moments (if not, you've made a mistake). These co-ordinates refer to the current block that your character occupies, and so have no decimal point. Comparing these with the co-ordinates at the top-left, you will see that these are just the result of rounding down those decimals to integers (for example, -1.1 is rounded down to -2). Your character's co-ordinates are available via "mc.player.getPos()," so in some ways "getTilePos()" is superfluous, but it saves three float to int coercions, so we may as well use it. The API has a nice class called Vec3 for dealing





with three-dimensional vectors, such as our player's position. It includes all the standard vector operations, such as addition and scalar multiplication, as well as some other more exotic stuff that will help us later on.

» We can also get data on what our character is standing on. Go back to your Python session and type:

```
curBlock = mc.getBlock(x, y - 1, z)
mc.postToChat(curBlock)
```

» Here, "getBlock()" returns an integer specifying the block type: 0 refers to air, 1 to stone, 2 to grass, and you can find all the other block types in the file "block.py" in the "~/picraft/minecraft" folder we created earlier. We subtract 1 from the y value, because we are interested in what's going on underfoot—calling "getBlock()" on our current location should always return 0, because otherwise we would be embedded inside something solid or drowning.

» As usual, running things in the Python interpreter is great for playing around, but the grown-up way to do things is to put all your code into a file. Create the file "~/picraft/gps.py" with the following:

```
import minecraft.minecraft as minecraft
import minecraft.block as block
mc = minecraft.Minecraft.create()
oldPos = minecraft.Vec3()
while True:
  playerTilePos = mc.player.getTilePos()
  if playerTilePos != oldPos:
    oldPos = playerTilePos
    x = playerTilePos.x
    y = playerTilePos.y
    z = playerTilePos.z
    t = mc.getBlock(x, y – 1, z)
    mc.postToChat(str(x) + ' ' + str(y) + ' ' + str(z) + ' ' + str(t))
```

3 RUN YOUR PROGRAM

Now fire up *Minecraft*, enter a world, then open up a terminal, and run your program:

```
$ python gps.py
```

» The result should be that your co-ordinates and the BlockType of what you're standing on are displayed as you move about. Once you've memorized all the BlockTypes (joke), Ctrl-C the Python program to quit.

» We have covered some of the "passive" options of the API, but these are only any fun when used in conjunction with the more constructive (or destructive) options. Before we move on, we'll cover a couple of these. As before, start *Minecraft* and a Python session, import the *Minecraft* and block modules, and set up the "mc" object:

```
posVec = mc.player.getTilePos()
x = posVec.x
y = posVec.y
z = posVec.z
for j in range(5):
  for k in range(x - 5, x + 5)
    mc.setBlock(k, j, z + 1, 246)
```

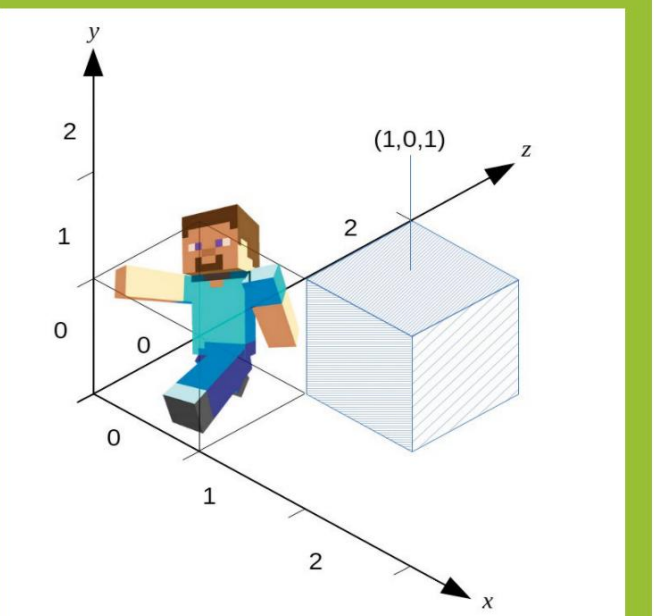
» Behold! A 10 x 5 wall of glowing obsidian has been erected adjacent to your current location. We can also destroy blocks by turning them into air, so we can make a tiny tunnel [**Image C**] in our obsidian wall like so (assuming you didn't move since inputting the previous code):

```
mc.setBlock(x, y, z + 1, 0)
```

DUDE, WHERE'S MY STEVE?

Here we can see our intrepid character (Steve) inside the block at (0,0,0). He can move around within that block, and a few steps in the x and z directions will take Steve to the shaded blue block. On this rather short journey, he will be in more than one block at times, but the *Minecraft* API's "getTilePos()" function will choose the block which contains most of him.

Subtleties arise when trying to translate standard concepts, such as lines and polygons, from Euclidean space into discrete blocks. A 2D version of this problem occurs whenever you render any kind of vector graphics. Say, for instance, you want to draw a line between two points on the screen, then unless the line is horizontal or vertical, a decision has to be made as to which pixels need to be colored in. The earliest solution to this was provided by Jack Elton Bresenham in 1965, and we will generalize this classic algorithm to three dimensions over the page.



4 BECOME A HOMEMAKER

Now we're *au fait* with the basics of the API, it's time to get creative. Building a house is hard, right? Wrong. With just a few lines of sweet Python, your dream home can be yours. Provided your dream home is a fairly standard box construction. If your dreams are wilder, all it takes is more code. You will never have to worry about building permits, utility connection, or accidentally digging up an ancient burial ground (unless you built it first).

›› It never actually rains in *Minecraft Pi*, so a flat-roof construction will happily suit our purposes just fine. We kick off proceedings by defining two corners for our house: v1 is the block next to us in the x direction, and one block higher than our current altitude, whereas v2 is an aesthetically pleasing distance away:

```
pos = mc.player.getTilePos()
v1 = minecraft.Vec3(1,1,0) + pos
v2 = v1 + minecraft.Vec3(10,4,6)
```

›› Now we create a solid stone cuboid between these vertices, and hollow it out by making a smaller interior cuboid of fresh air:

```
mc.setBlocks(v1.x,v1.y,v1.z,v2.x,v2.y,v2.z,4)
mc.setBlocks(v1.x+1,v1.y,v1.z+1,v2.x-1,v2.y,v2.z-1,0)
```

›› Great, except our only means of egress and ingress is via the skylight, and a proper floor would be nice [**Image D**]. If you're standing in a fairly flat area, you'll notice that the walls of your house are hovering one block above ground level. This space is where our floor will go. If your local topography is not so flat, your house may be embedded in a hill, or partly airborne, but don't worry—the required terraforming or adjustments to local gravity will all be taken care of. Let's make our rustic hardwood floor:

```
mc.setBlocks(v1.x,v1.y-1,v1.z,v2.x,v1.y -1,v2.z,5)
```

›› The windows are just another variation on this theme:

```
mc.setBlocks(v1.x,v1.y+1,v1.z+1,v1.x,v1.y+2,v1.z+3,102)
mc.setBlocks(v1.x+6,v1.y+1,v1.z,v1.x+8,v1.y+2,v1.z,102)
mc.setBlocks(v2.x,v1.y+1,v1.z+1,v2.x,v1.y+2,v1.z+3,102)
mc.setBlocks(v1.x+2,v1.y+1,v2.z,v1.x+4,v1.y+2,v2.z,102)
```

›› The roof uses the special half block 44, which has a few different types. Setting the blockType makes it wooden:

```
mc.setBlocks(v1.x,v2.y,v1.z,v2.x,v2.y,v2.z,44,2)
```

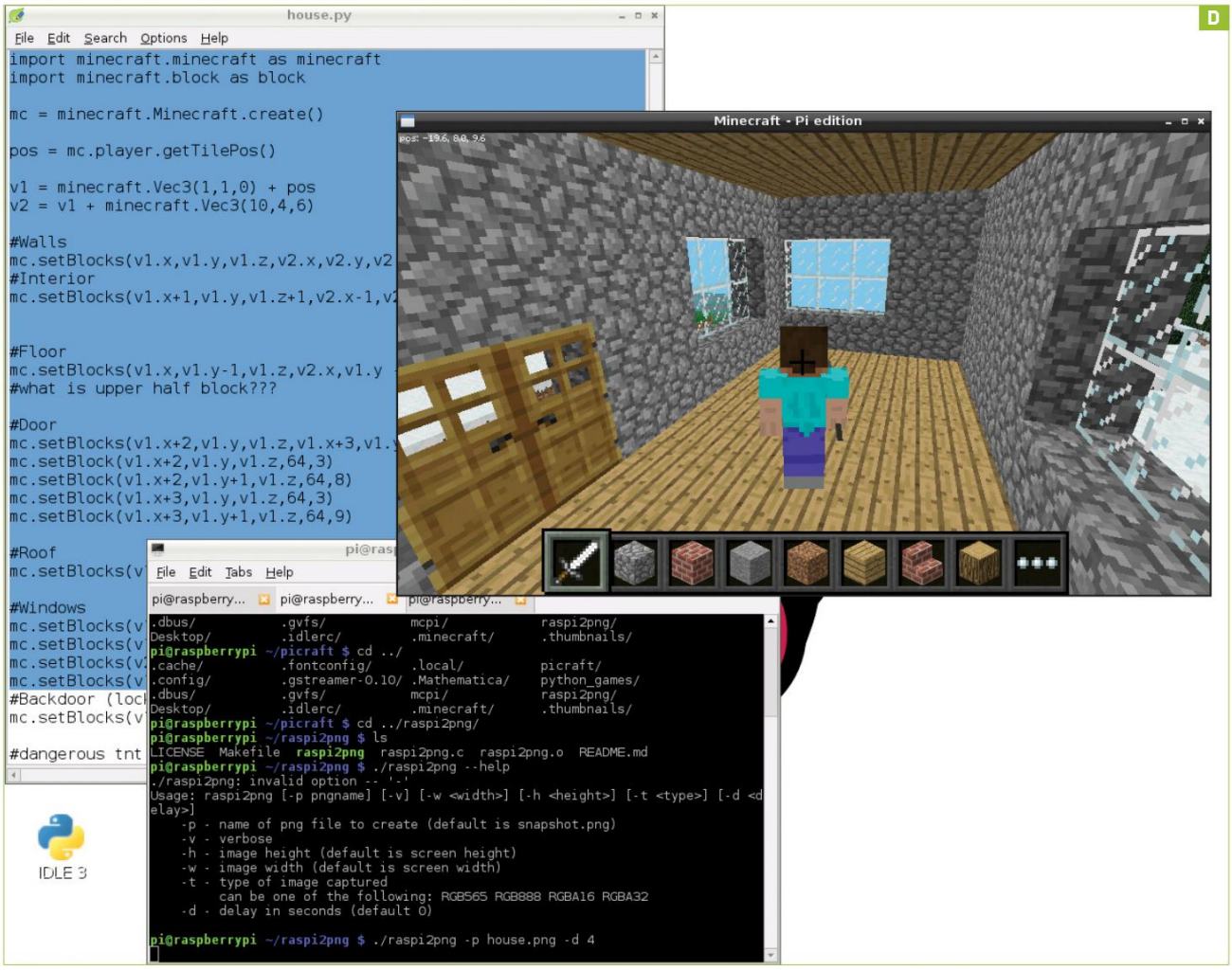
›› The door is more complicated—the gory details are in the box opposite—but the following three lines do the job:

```
mc.setBlocks(v1.x+2,v1.y,v1.z,v1.x+3,v1.y,v1.z,64,3)
mc.setBlock(v1.x+2,v1.y+1,v1.z,64,8)
mc.setBlock(v1.x+3,v1.y+1,v1.z,64,9)
```

›› Having lovingly constructed our property, the next step is to come up with inventive ways of destroying it. We've mentioned that TNT can be made live, so that a gentle swipe with a sword will cause it to detonate. It would be trivial to use setBlocks to fill your house with primed TNT, but we can do better. Allow us to introduce our trebuchet.

5 SIMPLE MECHANICS

Rather than simulating a projectile moving through space, we instead trace its parabolic trajectory with



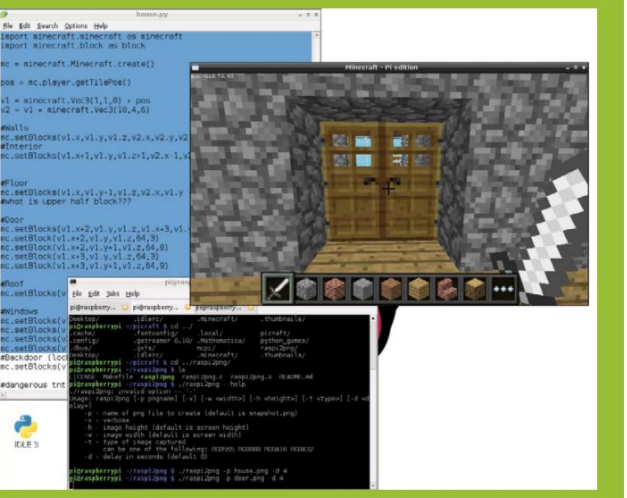
D

DOUBLE DOOR DETAILS

Putting doors into our house is our first encounter with the additional blockData parameter. This is an integer from 0 to 15, and controls additional properties of blocks, such as the color of wool and whether or not TNT is live. Our door occupies four blocks, and is aligned in the x direction. It's recessed slightly back from the surrounding walls, closed, and has the handles helpfully placed toward the middle. These properties are controlled by various bits of the blockType. We number the four bits from the right-most bit 0 to the left-most bit 3, and in little-endian notation, so that 8 is represented in binary as 1000. Bit 3 is set if the block is part of the top section of a door. If this is the case, bit 0 is the only other bit of concern—it determines the placement of the handles and hinges. Top sections of doors thus have blockType 8 or 9.

For the bottom sections, we have the following bit assignments:

bit 3.....off
bit 2.....door is open



bit 1.....door recessed
bit 0.....alignment (off=x, on=z)

The top sections must be placed after the bottom ones, because they inherit their properties from their inferiors.

hovering TNT. Detonating the origin of this trajectory will initiate a satisfying chain reaction, culminating in a big chunk of your house being destroyed. First we will cover some basic 2D mechanics. In the absence of friction, a projectile will trace out a parabola determined by the initial launch velocity, the angle of launch, and the gravitational acceleration, which on Earth is about $9.81 ms^{-2}$.

›› As a gentle introduction, we will fiddle these constants so that the horizontal distance covered by this arc is exactly 32 blocks, and at its peak it will be 16 blocks higher than its original altitude. If blocks were meters, this fudge would correspond to a muzzle velocity just shy of $18 ms^{-1}$, and an elevation of 60 degrees. We will only worry about two dimensions, so the arc will be traced along the z axis, with the x co-ordinate fixed just next to our door. This is all summed up by the simple formula y = z(2- z/16), which we implement this way:

```
for j in range(33):
  height = v1.y + int(j*(2 – j/16.))
  mc.setBlock(v1.x+4,height,v1.z-j,46,1)
```

›› The final argument sets the TNT to be live, so have at it with your sword, and enjoy the fireworks. Or maybe not: The explosions will, besides really taxing the Pi's brain, cause some TNT to fall, interrupting the chain reaction, and preserving our lovely house. We don't want that, so we instead use the following code:

```
height = v1.y
ground = height - 1
j = 0
while ground <= height:
  mc.setBlocks(v1.x + 4,oldheight,v1.z - j,v1.x +  4,height,v1.z - j,46,1)
  j += 1
  oldheight = height
  height = v1.y + int(j * (2 - j / 16.))
  ground = mc.getHeight(v1.x + 4, v1.z - j)
```

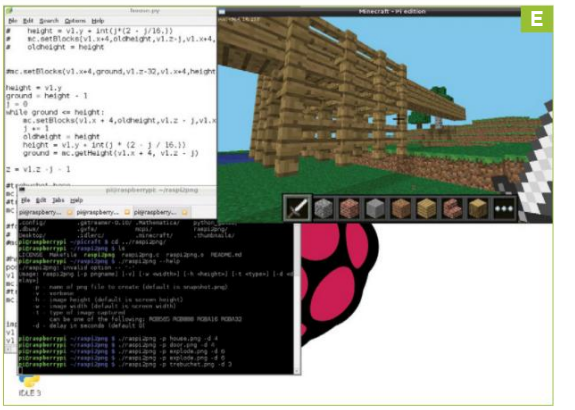
›› This ensures that our parabola is gap-free, and also mitigates against the TNT *arc-en-ciel* terminating in mid-air. We have dealt with this latter quandary using the "getHeight()" function to determine ground level at each point in the arc, and stop building when we reach it. Note that we have to make the "getHeight()" call before we place the final TNT block, because the height of the world is determined by the uppermost non-air object, even if that object is hovering.

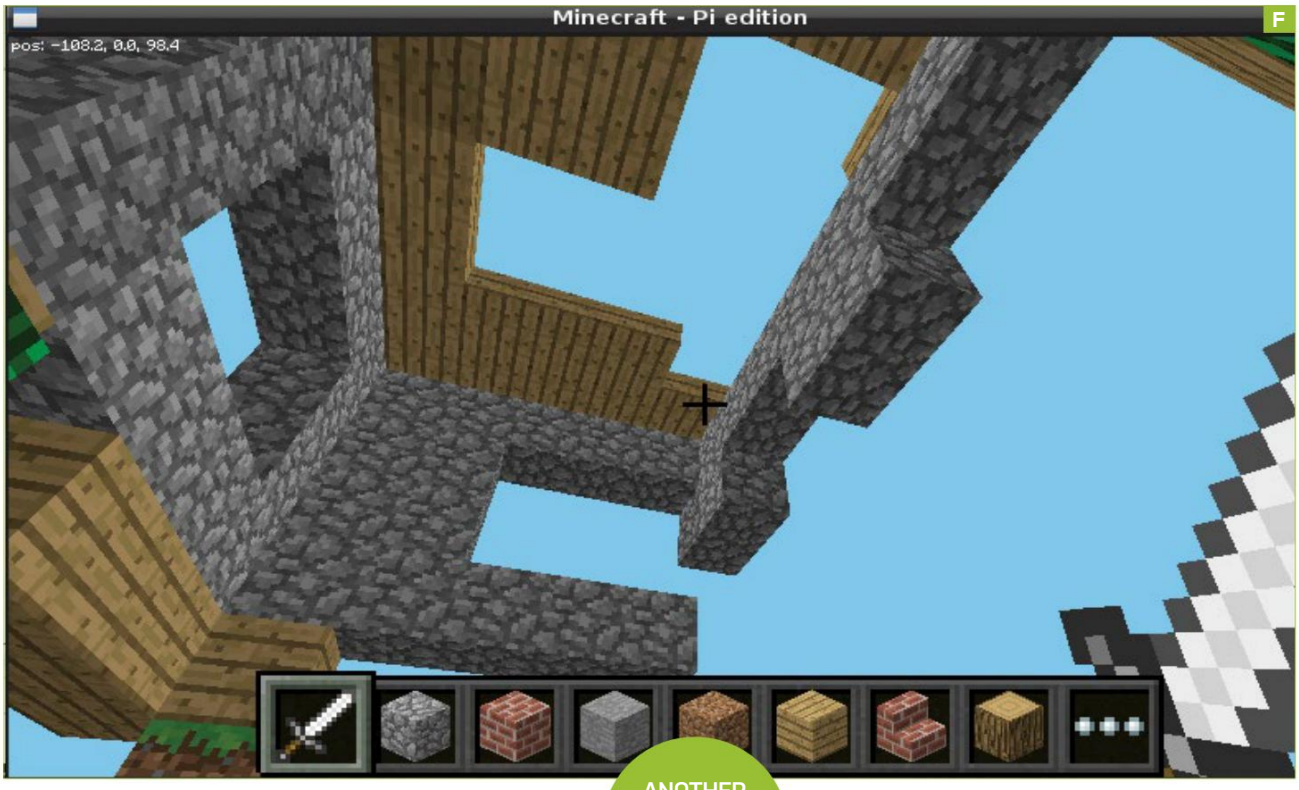
6 CREATE YOUR TREBUCHET

If our construction exceeds the confines of the *Minecraft* world, you could just build another house in a better situation, or you could change "v1.z - j" to "max(-116,v1.z-j)" in the above loop [**Image E**], which would make a vertical totem of danger at the edge of the world. Now we have our trajectory, we can add the mighty siege engine:

```
z = v1.z -j - 1
mc.setBlocks(v1.x + 3, oldheight, z + 10, v1.x + 6, oldheight + 2, z + 7,85)
mc.setBlocks(v1.x + 4, oldheight + 2, z + 12, v1.x + 4, oldheight + 2, z + 1, 5)
```

›› Until now, we've aligned everything along a particular axis. Our house (before you blew it up [**Image F**]) faces the negative z direction, which might be akin to facing south, and this is also the direction along which our explosive parabola is traced. We could rotate everything 90 degrees, and the code would look much the same, though your house would look funny on its side. Things get complicated if we want to shed the yoke of these grids and right angles,





to work with angles of our choosing [Image G]. The problem is how to approximate a straight line when our units are blocks of fixed orientation rather than points.

ANOTHER PI TUTORIAL NEXT MONTH

7 TWO OR THREE DIMENSIONS?

A general 3D "drawline()" function will prove invaluable in your creations, enabling you to create diverse configurations, from parallelepipeds to pentagrams. What is required is a 3D version of the Bresenham algorithm. Pi guru Martin O'Hanlon's GitHub contains several wonderful *Minecraft Pi Edition* projects, including a mighty cannon from which this project takes its inspiration. Martin has a whole Python drawing class, which includes the aforementioned 3D line algorithm, but once you understand the 2D version, the generalization is straightforward.

» Let us imagine we are in a *Flatland*-style *Minecraft* world, in which we wish to approximate the line in the (x,y) plane connecting the points (-2,-2) and (4,1). This line has the equation y = 0.5x - 1. The algorithm requires that the gradient of the line is between 0 and 1, so in this case we are fine. If we wanted a line with a different slope, we can flip the axes to make it conform. The crux of the algorithm is the fact that our pixel line will fill only one pixel (block) per column, but multiple pixels per row. Thus, as we rasterize pixel by pixel in the x direction, our y co-ordinate will either stay the same or increment by 1. Some naive Python would then be:

```
dx = x1 – x0
dy = y1 – y0
y = y0
error = 0
grad = dy/dx
for x in (x0,x1):
 plot(x,y)
 error = error + grad
 if error >= 0.5:
  y += 1
  error -= 1
```

where "plot()" is some imaginary plotting function and "grad" is between 0 and 1. Thus we increment y whenever our error term accumulates sufficiently.

» Bresenham's trick was to reduce all the calculations to integer operations. Nowadays, we can do floating point calculations at speed, but it is still nice to appreciate these hacks. The floating point variables "grad" and "error" arise due to the division by dx, so if we multiply everything by this quantity, and work around this scaling, we are good to go.

» To get this working in three dimensions is not so much of an abstractive jump. We find which is the dominant axis (the one with the largest change in co-ordinates), and flip things around accordingly, moving along the dominant axis one block at a time, and incrementing the co-ordinates of minor axes as required. We have to pay attention to the sign of each co-ordinate change, which we store in the variable "ds." The "ZSGN()" function returns 1, -1, or 0 if its argument is positive, negative, or zero respectively; we have left coding this as an exercise for you. We use a helper function "minorList(a,j)," which returns a copy of the list "a" with the "jth" entry removed. We can code this using a one-liner thanks to lambda functions and list slicing:

```
minorList = lambda a,j: a[:j] + a[j + 1:]
```

8 AXES TO GRIND

Our function "getLine()" will take two vertices, which we will represent using three-element lists, and return a list of all the vertices in the resulting 3D line. All of this is based on Martin's code. The first part initializes our vertex list and deals with the easy case, where both input vertices are the same. Here our line is just a single block:

```
def getLine(v1, v2):
  if v1 == v2:
    vertices.append([v1])
```

» After this it gets ugly. We set up the list of signs, "ds," and a list of absolute differences (multiplied by two), "a." The "idx =" line is bad form—we want to find our dominant axis, thus the index of the maximum entry in "a." Using the "index()" method with "max" means we are looping over our list twice, but as this is such a short list, we shan't worry—it looks much nicer. We refer to the dominant co-ordinates by "X" and "X2." Our list "s" is a re-arrangement of "ds," with the dominant co-ordinate at the beginning. And there are some other lists to keep track of the errors. The variable "aX" refers to the sign of the co-ordinate change along our dominant axis.

```
  else:
    ds = [ZSGN(v2[j] - v1[j]) for j in range(3)]
    a = [abs(v2[j]-v1[j]) << 1 for j in range(3)]
    idx = a.index(max(a))
    X = v1[idx]
    X2 = v2[idx]
    delta = a[idx] >> 1
    s = [ds[idx]] + minorList(ds,idx)
    minor = minorList(v1,idx)
    aminor = minorList(a,idx)
    dminor = [j - delta for j in aminor]
    aX = a[idx]
```

9 FINAL TOUCHES

With all that set up, we can delve into our main loop, in which vertices are added, differences along minor axes examined, errors recalculated, and major co-ordinates incremented. Then we return a list of vertices.

```
    loop = True
    while(loop):
      vertices.append(minor[:idx] + [X] + minor[idx:])
      if X == X2:
        loop = False
      for j in range(2):
        if dminor[j] >= 0:
          minor[j] += s[j + 1]
          dminor[j] -= aX
        dminor[j] += aminor[j]
      X += s[0]
  return vertices
```

» We will test this function by making a mysterious beam of wood next to where we are standing.

```
v1 = mc.player.getTilePos() + minecraft.Vec3(1,1,0)
v1 = minecraft.Vec3(1,1,0) + pos
v2 = v1 + minecraft.Vec3(5,5,5)
bline = getLine([v1.x,v1.y,v1.z],[v2.x,v2.y,v2.z])
for j in bline:
 mc.setBlock(j[0],j[1],j[2],5)
```

That's it! Using *Minecraft Pi Edition* is a great way to practice coding in Python. You'll have so much fun [Image H], you'll probably not even realize you're learning!

Play Xbox One and PS4 Games on PC

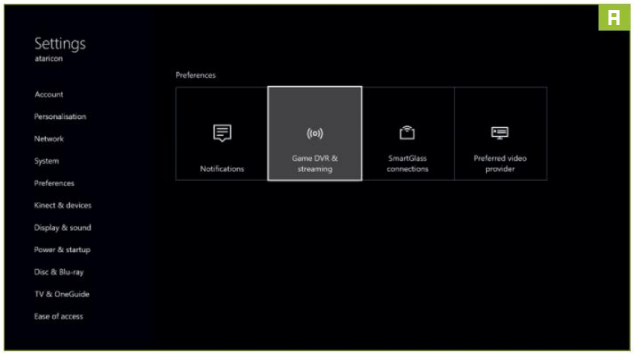
YOU'LL NEED THIS

CONSOLE
You need the muscle of a current-gen box running the absolute latest firmware.

WINDOWS 10
Xbox One requires Win 10, but Win 8.1 will do the trick for PS4.

WHY, DEAR READER, should you be chained to your TV when you want to play a console game? And—sacrilegiously—why should you feel tied to the (awesome) cycle of constant upgrades your PC requires to keep up with the latest gaming standards? Maybe you've got a laptop, a supremely portable but doggedly non-upgradeable machine. What then?

Well, fear not. If you're happy with the quality of console gaming, and you've already kitted out your lounge with a modern console, you can stream your gaming to your PC, and play anywhere in the house (or, in the case of the PS4, anywhere with a fast enough Internet connection). There are even added benefits beyond the ability to game on the throne. Those expensive 360 controllers your Xbox One doesn't support? Plug them in to your PC while streaming, and they'll work just fine. That old monitor with no HDMI input? Hey, use VGA! **–ALEX COX**



1 HOOK IT UP

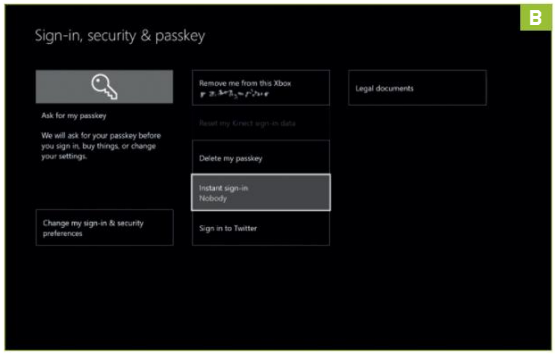
We'll concentrate on streaming the Xbox One in this main part of the tutorial—look to the right if you're streaming your PS4. But the primary step counts for both: Connect them to the finest network you can get your hands on. A wireless network barely cuts it—there's a lot of data to stream fast, particularly if you don't want your games to look like a 1999 RealPlayer video hidden behind a layer of petroleum jelly. This counts for both ends, so grab those Ethernet cables if possible, and pick up some high-end powerline networking kit if applicable.

2 XBOX ON

Switch on your console—hooked up to your TV for now—and make sure it's completely up to date with the latest firmware. This usually means a massive download from Microsoft's oh-so-sluggish servers, but when it's done, you'll be ready to take the necessary steps to allow streaming. In the Xbox One's left-hand vertical menu, hit the cog icon, select "All settings," and head down to "Preferences." You'll find all the options you need in the "Game DVR & streaming" menu. It's quite possible your Xbox is already configured to share itself, the promiscuous thing, but if it isn't, just tick "Allow game streaming to other devices" [**Image A**].

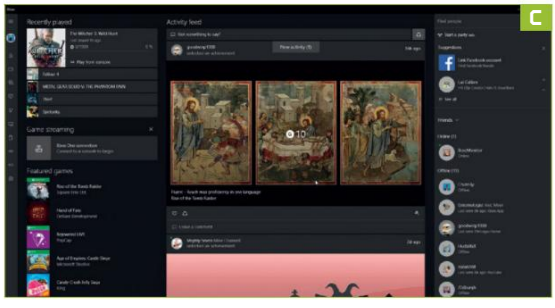
3 SORT SECURITY

Here's a slightly annoying thing: If you want this to work reliably without having to commandeer the TV each time you want to get started, you'll need to set your Xbox to automatically sign in to your Xbox Live account without requiring a passkey. Feel free to skip this step if you have family members who get a bit trigger-happy with your credit card, but you'll need to sign in manually each time you want to stream if you do. Go to the "Account" menu, open up the sign-in options, select "Instant sign-in," then "Use instant sign-in" [**Image B**]. Once you've done this, you'll need to switch your Xbox on to get streaming—you can do this with your wireless controller. If you really need a way to switch on your Xbox remotely, try the Python script at https://github.com/Schamper/xbox-remote-power—it's a bit beyond the scope of this tutorial.



4 APP INSTALL

Windows 10's Xbox app is—apart from being a good way to manage your Xbox Live account—the component that does the streaming on the PC end. First up, make sure it's installed by going to the Windows Store, and searching for "Xbox," as we've spotted a few early-upgrade installs of Windows 10 that don't have it on board.



Next, make sure it's fully updated, as streaming is glitchy if you don't have the latest software on either end. Finally, you'll need to launch the app and sign in to it with your Xbox Live credentials—the same credentials signed into your Xbox One. One more roadblock: If your Windows user account doesn't match these details, you may encounter problems here. If you're stuck, create a new user account using your Xbox Live login, and run the Xbox app from there.

5 CONNECT

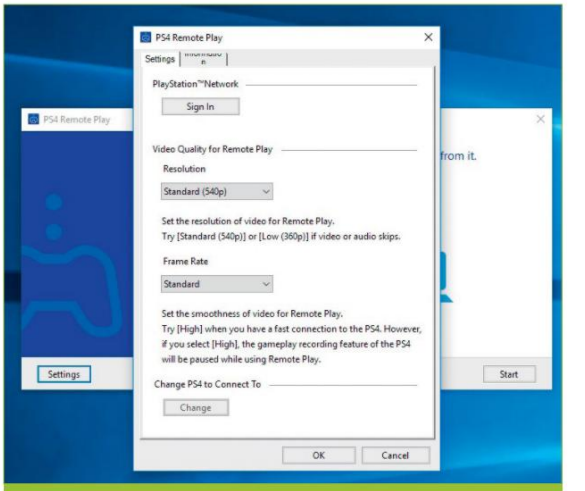
The Xbox app looks a lot like the Xbox One dashboard—confusingly so at times. Look on the left for a menu marked "Connect," and find your Xbox One in the list that appears. This synchronizes the two, giving you the option in the main menu of the Xbox app to either stream directly—which will put you in control of the Xbox One dash [**Image C**]—or just to select an installed game and stream that. Plug in an Xbox controller (or use your wireless controller, if you're close enough to your console), and you're away.

6 TROUBLESHOOTING

Here's where you're going to have to face facts about your network. If it's not up to scratch, you may see graphical glitches [**Image D**], hear audio squelches, or face the indignity of desynchronized gameplay, speeding up and slowing down as your PC struggles to catch up. If this happens to you, move your mouse to the top-right icon, and tweak the quality of streaming. You may find the lower levels acceptable, particularly given your new levels of streaming convenience.

7 TAKE IT FURTHER

Note that you don't have to stream within your house if you want to share your gameplay with the world—Twitch streaming is built into the Xbox One, and its options can be found in the "Preferences" section. Don't expect to use both streaming options at once, though, unless you're rocking some sort of extreme übernetwork. And if this has whetted your whistle, look into Steam's Remote Play features, and take advantage of that gaming rig now you know that your network can handle it.



PS4 REMOTE PLAY

The PS4 has been a streaming beast for some time, piping its games to such unloved and unpurchased devices as the PlayStation TV and PlayStation Vita. As part of the April 3.5 firmware update, Sony seems to have admitted such failures, and opened its borders to streaming elsewhere, including, yes, the PC. Start by making sure your PS4 is running at least 3.5 firmware—it should have come through as an automatic update, but if it hasn't (if you have disabled automatic updates, for example), head to "Settings → System Software Update" to get it installed.

Now prepare your PC. There's not a huge system spec demand—2GB RAM, Core i5-560M—but, obviously, the better your machine is, the easier it'll cope with the demands of streaming 720p 60fps gameplay with minimal lag. Unlike the Xbox solution, Remote Play works online, so make sure you've also got a decent broadband connection—Sony recommends at least 12Mb/s. Next, head to https://remoteplay.dl.playstation.net/remoteplay/lang/gb/index.html to grab the PC client and install it.

Back on your PS4, make sure it's your primary device ("Settings → PlayStation Network → Account Management → Activate as your primary PS4"), then ensure Remote Play is activated ("Settings → Remote Play connection settings"). Return to your PC, run the Remote Play app, and sign in with the same PSN credentials you've used on your PS4. Pick your resolution (start with the highest, as you can always notch it down later), hit "Start," and you'll see your PS4 menu. Now just use a USB cable to plug a PS4 controller into your streaming device, and you should be ready to play. Try it from a remote location away from your home network, too—you may have to dial down the settings somewhat, but it should work fine.

Create Reflections in Photoshop

YOU'LL NEED THIS

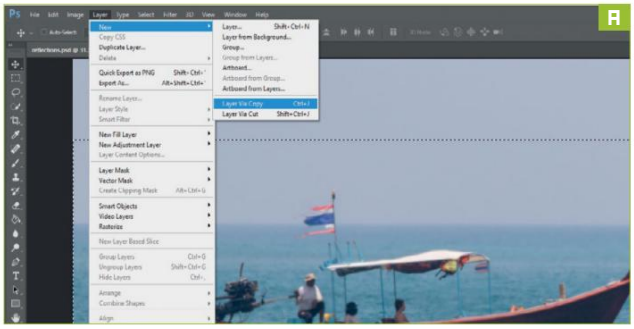
ADOBE PHOTOSHOP
Subscribe to various Adobe packages at www.adobe.com.

AN APPROPRIATE PHOTOGRAPH
A picture including water is most obvious.

A REFLECTION OCCURS when a surface bounces back enough of the light that has, in turn, bounced from another object, without distorting or diffusing it so much that it becomes unrecognizable. The blue of the sea is said to be a reflection of the sky above, while in Oregon, a lake reflects Mount Hood so perfectly it's been called Mirror Lake.

Not everything is a mirror, however, and that distortion and diffusion can be harnessed by digital artists to make reflections that look natural—the great pitfall of trying to add a reflection to an image is ending up with an unrealistic result, and it's a very easy state to find yourself in.

Reflections, of course, occur perfectly naturally, as anyone who's ever found themselves captivated by their own face looking back at them from a pool of water can attest. That sort of thing tends to end badly, though, so here we'll show you how to add a reflection where one isn't present, using Photoshop—and, hopefully, without the assistance of vengeful goddesses. –IAN EVENDEN


A

1 PICK SOURCE IMAGE

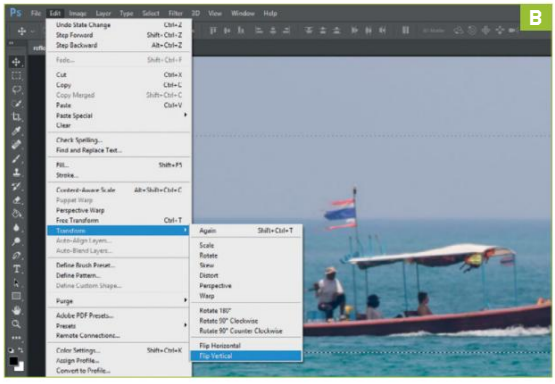
As ever, the trick to getting a good effect is to choose your source picture carefully. The longtail boat in our pic was plying its trade on Rajjaprabha Dam Reservoir in Thailand, but the murky nature of the water means it's not reflected in the surface below.

2 SELECT AREA TO REFLECT

We're doing this in the latest version of Photoshop CC, but there's nothing here you couldn't do in Elements, because all the tools you need are there, but they may be found in slightly different places. The first thing to do is to select the area you want to reflect. You can make life easier by choosing something rectangular, but our boat is a very uneven shape. Photoshop comes with a variety of selection tools, from the simple Rectangular Marquee to the freehand Lasso, and the clever Magic Wand and Quick selection tools, which try to guess what your intentions are (with varying degrees of success). The Wand, which selects areas of contiguous color, won't be much use to us here, and the Lasso will be fiddly, so we're going to use the Rectangular Marquee, and worry about erasing the bits we don't want later. However you do it, make sure everything you want to reflect is inside the line of marching ants that marks the boundary of the selection.

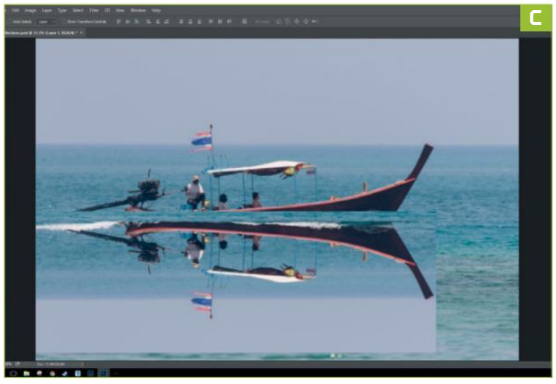
3 CREATE NEW LAYER

Once you've got the area you want to reflect selected, it needs to be copied to another layer. Go to the "Layer" menu, and select "New," then "Layer Via Copy" [**Image A**]. This places a copy of your selected pixels precisely over the top of the original ones. You may not notice any change in the image as it's displayed, but a "Layer 1" will appear in the Layers palette.


B

4 FLIP LAYER

A reflection is a mirror image of the original, so we need to flip our new layer over. To do this, make sure the new layer is selected in the Layers palette, then head to the "Edit" menu, select "Transform," then "Flip Vertical" [**Image B**]. You'll notice the difference this time, because the reflection will now be partially covering the original, and you'll need to shift it down using the Move tool, to get it in the right position at the bottom of the original item. Hold the Shift key while you're moving it, and it will be constrained in a single direction, meaning you won't wobble from side to side as you drag the mouse, and then have to spend ages lining it up perfectly.


C

5 CHANGE BLEND MODE

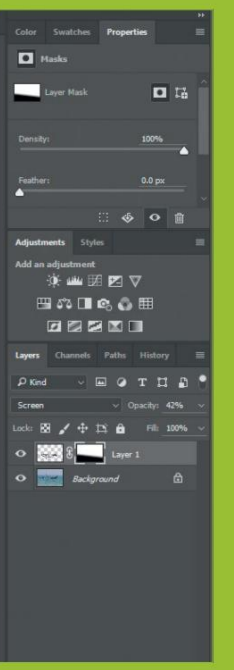
The result of all this probably doesn't look very natural [Image C]. The next step will help fix that, and it's to change the blending mode, so our two layers interact in a slightly different way. Think of it as the light from below, passing through Layer 1 on top, being allowed through, subject to some rules. At the moment, with the blend mode at Normal and 100%, none of it can get through. We're going to change it to a mode that allows lighter colors to show through—either Lighten or Screen, depending on what looks best for your image. Make sure "Layer 1" is selected, using the drop-down menu on the Layers palette. We're using "Screen."

6 ERASE UNWANTED PARTS

You should be able to see how your finished reflection will look. We're going to use the Eraser tool to remove unwanted bits of the original image, left over from where we were lazy with our selecting [Image D]. You can change the Blend mode back to Normal while you do this, if it makes it easier. There's no shortcut to this, and you'll have to do it freehand—keep the edge of your Eraser quite soft to minimize hard transitions, as these will catch the viewer's eye and look unrealistic. Once you're done, change it back to Screen or Lighten, and fade down the Opacity using the slider to the right of the Blend mode drop-down. We turned it down to 42 percent, but do whatever looks best.

7 FINAL TOUCHES

Finally, we're going to fade the reflection out with a Layer Mask. Make sure you've got "Layer 1" selected, then click the "Layer Mask" button at the bottom of the Layers palette. A new rectangle should appear on your layer's entry in the palette. Next, make sure you have black and white as your active colors, by pressing D, and select the Gradient tool, often found hiding behind the Paint Bucket. Use this to paint a gradient from top to bottom on your image—one swipe of the mouse should do it, again constraining it with the Shift key to lock it in the vertical. This should fade out your reflection so it's strongest where it meets the original [Image E]. Experiment to see what looks best, then save as a PSD, and flatten the layers if you want to export it as a JPEG.



THE LAYER MASK

The "Layer Mask" button at the bottom of the Layers palette looks like a rectangle with a hole in it, and this is roughly how it works. Anything within the mask will vanish, showing through what's underneath, and you can paint a mask on using black and any of the painting tools, as long as you're editing a layer's Mask. By using the Gradient tool, we've created a smooth fade from black to white, enabling a natural blend of the reflection and the background as it moves further away from the boat, so the choppy little waves of the lake surface show through, adding to the natural look of the effect. If it were completely smooth, you'd know immediately that it had been added in Photoshop.

BUILD IT

ZAK STOREY **STAFF WRITER**

The Miniature Dream PC

A little water cooling here, a radiator or two there, and one hell of a lot of processing power

LENGTH OF TIME: **16–20 HOURS** | LEVEL OF DIFFICULTY: **HARD**

THE PERFECT ALL-ROUNDER

FOR THE PC ENTHUSIAST in today's climate, our work has never been as diverse, as interconnected. Just take a step back for a moment, and consider how much more you do on your system now than, say, 10 years ago. We game, we render, we design, we write, we create, we produce. There's no such thing as the perfect PC, because that would be different for all of us, but what if you wanted to push the limits, to reach beyond the mundane, and to take aesthetic design style and blend it with the craziness of computational processing power?

Well, that's what we're aiming to do here. The idea is to build an insanely powerful ITX system, full of the best and the most brilliant hardware we could find to satisfy all of those different needs. So we can push four million AAA pixels in-game, render 4K videos, record audio, and do our work in complete silence, while retaining a beautiful system you'd be proud to showcase on your desk.

HARDLINE LIQUID COOLING

ULTIMATELY, THIS BUILD was all about encapsulating the feel of our Dream Machines, while condensing it down into a smaller, more affordable form factor. Liquid cooling was our first port of call, and we chose the NZXT Manta to house all of our meaty hardware. The backbone of this rig, we decided, was going to be the Asus Z170i Pro Gaming, thanks to its easily moddable heatsinks and hidden M.2 slot. On top of that we chose an Intel Core i7-6700K pre-binned CPU, clocking in at 4.8GHz, available online from http://siliconlottery.com.

For graphical processing, we went for an XFX Radeon R9 Fury X. The HBM will work a treat, and thanks to some amazing tomfoolery from EKWB's design team, once the waterblock is attached, it's actually a single-slot card.

Then we threw 32GB of HyperX Savage 2,666MT/s DDR4 into the mix—brilliant capacity and performance, and it matched our build scheme, too. For storage, we opted for a Samsung 950 Pro 512GB for the operating system, and a further 1TB of storage from the OCZ Trion 100 we still had kicking around the office. More than enough super-fast storage to sink your teeth into.

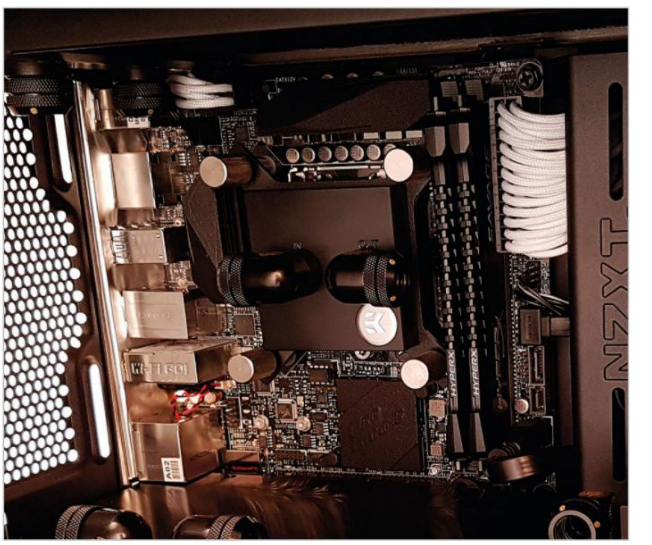
INGREDIENTS

PART		STREET PRICE
Case	2x NZXT Manta	$280
Motherboard	Asus Z170i Pro Gaming	$165
CPU	Intel Core i7-6700K @ 4.8GHz	$460
Memory	HyperX Savage 32GB (2x 16GB) 2,666MT/s	$194
GPU	XFX Radeon R9 Fury X	$630
PSU	Corsair AX1200i	$310
SSD 1	Samsung 950 Pro 512GB	$333
SSD 2	OCZ Trion 100 960GB	$200
Watercooling & Accessories	Waterblocks, piping, radiators, reservoirs, fittings, coolant, and fans	$1,128
Total		$3700

1 CHOOSING THE PERFECT CASE

THE FIRST THING you have to consider whenever you're about to embark on a water-cooled adventure is what chassis you're going to house your new machine in. The bigger rigs tend to be easier to work in, on the whole, because there's more room inside for you to fiddle around, but for us, ITX was the name of the game. NZXT's Manta looks stunning, and can house a 36mm-deep 240mm rad in the roof, and a meatier 240mm in the front, as well. The only problem was deciding where to mount the res. In the end, we had to drill into the floor, just to the right of the GPU, to add a mounting point for a Phanteks Evolv pump/res mount for our EKWB DDC combi. It still looks classy, and gave us just enough room to maneuver in. Although we're pretty thankful we didn't opt for a longer graphics card here....

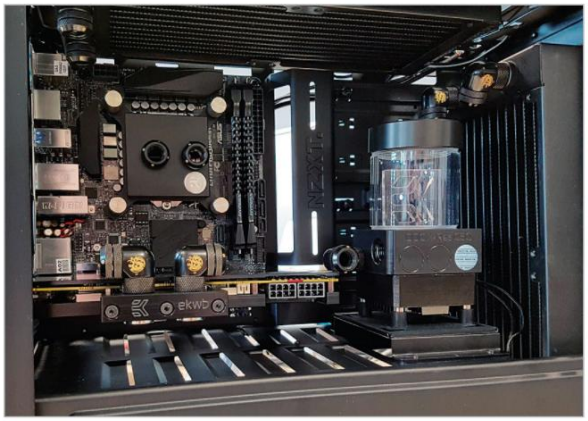
2 SPRAYING THE MOTHERBOARD



GETTING THE PERFECT MOTHERBOARD for this build was particularly difficult. The trick was to find a traditionally oriented Z170 ITX board, with power connectors in the correct place, an M.2 slot, and the whole thing styled in black. Unfortunately, being so choosy left us with very few options. In the end, we decided to compromise a little on the color, and go with the Z170i Pro Gaming. To get the color scheme we wanted, it was a simple case of taking the heatsinks off, masking off everything except the red accents, and then applying a couple of layers of Plasti Dip to hide those color-clashing gaming stripes. Because Plasti Dip is a natural insulator, spraying only over the red accents would ensure we wouldn't be plagued by ridiculously high VRM temps, which we would have ended up with if we had sprayed the entirety of the heatsinks.

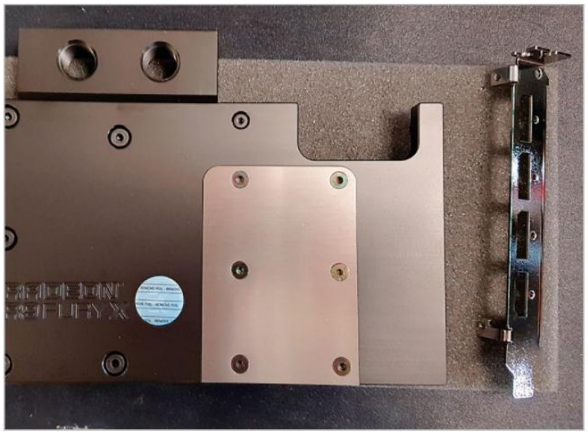
3 PLANNING TUBING RUNS

TUBING RUNS are always going to be tricky to plan in advance—the best advice we can give you is to invest in some angled rotary fittings, especially for hard tubing. They make life so much easier once everything is in your hands. When building any water-cooled rig, you should go through two separate builds. The first to ensure all of your hardware works prior to attaching waterblocks. Then the second prefit just to see where all of your hardware will lie, and what runs you may have to do. In our case, this was incredibly useful, because we learned pretty quickly that our initial idea to mount the combi resevoir to the radiator just wasn't going to work in such a tight chassis.



4 SINGLE-SLOT GPUS

THE DREAM, the ambition, the single-slot, water-cooled flagship card. EKWB provides a stunningly clean single-slot adapter with its Fury X waterblock, enabling the Fury X to be a truly beautiful, compact powerhouse. Couple that with a full cover backplate, and owf! Well, we'll let the photography do the talking. When installing GPU waterblocks, follow the instructions to the letter; there's no messing around here. If you don't make the right contacts here with the block, you can end up short-circuiting your card, or worse. That said, EKWB's EK-FC Fury X block was quite straightforward—the hard part was removing that noisy stock cooler off the original Fury X.



5 SUPER-STEALTH STORAGE

YOU KNOW WHAT we like more than alliteration? Hidden storage. And that's what we managed to achieve fairly seamlessly. The inclusion of an M.2 slot on the rear of the Asus Z170i Pro Gaming is a godsend—although incredibly inaccessible once installed in a water-cooled loop, it's a great way of keeping your M.2 drives cool and out of the way, avoiding any potential eyesores. For our 1TB drive, we simply hid that way down below the PSU cover. Annoyingly, NZXT's SSD mounting points place most SSDs upside down, as far as the label goes, and that's just not good enough for this aesthetic build. Still, it's the performance and capacity we're after—we have enough glamor.

6 FILLING THE LOOP

FILLING ANY LOOP requires forethought and planning; there's always two things you have to consider. Firstly, where your fill port is going to be, and secondly, to ensure that your pump is gravity-fed. Running your pump dry is one of the worst things you can do, as the coolant acts as a natural lubricant for the ball bearing situated in the turbine. To save on size and to ensure this didn't happen, we opted for an EKWB DDC combi pump reservoir; its overall small form factor is a lifesaver for this build, and by mounting it on the bottom of the chassis, we have easy access to the top fill port for inserting our pearly white coolant. Perfect.

1 **We actually opted for two NZXT Mantas for this build. We loved the white variant, but the half black/white interior really clashed with the idea we wanted to bring to life here.**

2 **Although the Manta technically supports two 280mm radiators, you have to bear in mind that the top will only support radiators up to 36mm in depth—we opted for an EKWB CoolStream SE 240mm for the roof, and a PE 240mm for the front of the chassis.**

3 **Interior lighting is produced thanks to a Bitfenix Alchemy 30cm white LED strip, and two sets of dual 3mm white LEDs—these help bring attention to our hardware, and really make the interior pop.**

4 **For fans, we decided to opt for four Noctua NF-F12 IPPC variants, spinning at 2,000rpm. The best of the best, these babies are super-silent at a low rpm, incredibly powerful, and—most importantly for Noctua—black.**

PERFORMANCE IN AN ATTRACTIVE PACKAGE

FINISHING BUILDING this monster gave us a greater understanding and appreciation of hardline water cooling. As a rookie, it can be daunting, especially when you first start bending your tubing. It's difficult—you have to take a step back, deconstruct your system a few times, and decide what's the best way to run various tubing lines in your chassis. It's definitely a labor of love, but once complete, it's hard to argue that it doesn't look incredible.

But it's not all about how pretty your rig looks, but how she performs when pushed up against that rendering grindstone, right? So, to clarify on our overclocks, we achieved an impressively stable 5GHz on our Core i7-6700K, with 1.41V on CPU core voltage. We kept the 32GB (2x 16GB) HyperX Savage Black DDR4 at 2,400MT/s, because the increased frequency also increased the CAS latency, making it less than worthwhile. And we also left the Fury X at stock, because although it is possible to overclock the Fiji GPU inside, it's incredibly finicky to get stable enough, especially with high CPU overclocks.

All in all, this rig was quiet. Really quiet. Even under load, the most we saw was 60°C, and it still wasn't enough to make the fans kick in. As far as our rendering tests went, we were impressed; 1,074 is nothing to shake your head at, especially for a 4/8 processor. Graphically, the Fury X is certainly a contender—if you're not looking to overclock, it's a solid 1440p card. In *Batman: Arkham City,* we scored a healthy 101fps, and both 4K titles scored frame rates in the high 40s. Dropping anti-aliasing would dramatically improve performance, as it's often unnecessary—certainly at such high pixel densities.

During the build, we came across a few problems, notably positioning the reservoir. If you want to utilize dual 240mm rads in this build, attaching the reservoir to either via a bracket is a nightmare, and on top of that, a combo pump res just won't fit mounted on the center support beam. We had to ghetto mount our EKWB DDC pump on to the center of a Phanteks pump mount from an Evolv ATX, then drill that into the chassis' mid plate.

For liquid cooling, the Manta is an incredible feat of engineering. The fact it isn't stymied by that traditional ITX size, ensuring you get the most out of your liquid cooling, is right up our alley. And as far as utilizing a single PCIe slot goes? Well, most people don't use more than a single GPU, and for good reason: If you have the cash, you go for a better graphics card, as opposed to running SLI or CrossFire, and having to deal with the problems and slow updates associated with that.

BENCHMARKS

	ZERO-POINT	
CineBench R15 Multithread	1,387	1,074 (-23%)
CineBench R15 Single Thread	128	213 (66%)
X264 HD 5.0 (fps)	33.8	24.6 (-27%)
Batman: Arkham City 1440p (fps)	204	101 (-50%)
Tomb Raider 4K (fps)	87.5	46.8 (-47%)
Shadow of Mordor 4K (fps)	70.1	48.96 (-30%)
3DMark Fire Strike Ultra	8,016	3,989 (-50%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses a Core i7-5960X CPU, three GTX 980s, and 16GB RAM. *Arkham City* tested at 2560x1440 Max settings with PhysX off; *Tomb Raider* at Ultimate settings; *Shadow of Mordor* at Max settings.

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92 Lab Notes

The Avant Garde is no trendy art piece, but it delivers where it counts.

AVADirect Avant Garde

A tower of power

THE TERM "AVANT GARDE" is used to describe new, experimental, and often challenging ideas and techniques in the world of art. When we apply this term to a PC, one would expect something along the same lines. The AVADirect Avant Garde doesn't live up to its name, but that's not to say there's a lot to dislike about it. In fact, the name is about the only overstated thing about the rig.

The Avant Garde came to us packaged in a box within a box. That's no big surprise, given the PC is built into a Corsair 500R. The 500R is a great case, but it's not much to look at. It's design features don't look terribly sexy, and the layout is rather run-of-the-mill. But the thing stays cool, and offers plenty of space. AVADirect made sure to accent the case with LED lighting (controllable with an included remote), and mounted a big 200mm fan on the side panel to keep the video cards fed with cool air.

AVADirect has filled the 500R with top-tier components. A pair of GeForce GTX Titan X cards in SLI work together to push pixels for 4K gaming, while the beating heart is Intel's Core i7-6700K Skylake CPU. The pricey core components were rounded out by 32GB of Kingston HyperX 2,400MHz DDR4 RAM, a 1TB Samsung 850 Evo 2.5-inch SATA SSD, and a 4TB Seagate Barracuda 7,200rpm 3.5-inch HDD. They all found their home on the stunning Asus ROG Maximus VIII Formula mobo, and a 1,200W EVGA 80 Plus Platinum-rated PSU provided ample power.

It's worth noting that AVADirect chose to cool the Core i7-6700K with a Corsair H100i v2. There's a good reason for this: The PC we reviewed came overclocked to 4.8GHz. That's a full 20 percent overclock from the CPU's 4GHz stock clock, which AVADirect offers for a $106 premium. That's on par with our findings in terms of what Skylake can do. When we first reviewed Skylake K-model CPUs last August, we were able to get to 4.7GHz with a Core i7-6700K using an air cooler.

There's no such thing as a guaranteed stable overclock, as every piece of silicon differs slightly. While the 6700K held stable for our game and single-threaded benchmarks, it choked when it was time for our multithreaded x264 benchmark. We attempted to run the benchmark several times, and H.264 Encoder would crash whenever it came to the second pass of encoding. That's with the H100i's fans cranked up to maximum, too. At the end of the day, we had to drop the overclock to 4.7GHz for the encoder to remain stable.

We didn't encounter this problem with ProShow Producer 5, which also encodes video. However, ProShow Producer limits scaling with CPU cores, and doesn't seem to ever use more than four at a time. (With Hyper-Threading, the Core i7-6700K has eight logical cores.) Since graphics benchmarks aren't that CPU intensive, the graphics tests completed without incident.

As for how those tests scored, well, a pair of Titan Xs is nothing to sneer at. The Avant Garde scored an impressive 8,073 in 3DMark's Fire Strike Ultra 4K graphics test. That (just) beat our zero-point's 8,016, derived from three GTX 980s in SLI, and a Core i7-5960X. *Middle Earth: Shadow of Mordor* and *Tomb Raider* are our other 4K tests, and the Avant Garde cranked out 90fps and 97fps respectively in each. In *Batman: Arkham City,* the PC provided 237fps on average at 1440p.

Those scores represent quite an achievement, but not without caveats. At the time of writing, there aren't any 4K monitors with G-Sync and refresh rates over 60Hz that we've seen—display port is holding us back here. Unless you pay for a 4K G-Sync monitor, chances are you're running 4K at 60Hz with VSync, or you're running a 144Hz 1440p monitor. Either way, the Titans in this rig are pushing way more pixels than you'll ever see. For this reason, a model that sports a pair of GTX 980 Tis would be more than sufficient, and cost significantly less ($1,137 less, to be exact).

Most of us could call that a waste of power, but some may prefer the term "future-proofing." After all, games are just going to keep asking for more and more power to make their world more and more believable—particularly now that virtual reality is definitely a thing again. The fact that the Avant Garde is way beyond the minimum bar for either the HTC Vive or the Oculus Rift doesn't hurt. You'll be able to step into VR without worry. **–ALEX CAMPBELL**

VERDICT **8**

AVADirect Avant Garde

HIGH ART Titan Xs provide tons of pixel-pushing power; impressively overclocked; high-end motherboard provides lighting and water-cooling options.

BAD ART Overclock not always stable in multithreaded high-intensity workloads; the Corsair 500R is a great case, but visually uninspiring; Pricey.

$5,050 (as configured), http://avadirect.com

SPECIFICATIONS

CPU	Intel Core i7-6700K overclocked to 4.8GHz (overclocks vary)
RAM	32GB DDR4/2,400MHz
Motherboard	Asus ROG Maximus VIII Formula
Graphics	2x GeForce GTX Titan
CPU Cooler	Corsair H100i v2
Storage	1TB Samsung 850 Evo 2.5-inch SATA, 4TB Seagate Barracuda HDD
Optical	LG Blu-ray burner
Case/PSU	Corsair 500R/EVGA SuperNOVA 1200 P2

BENCHMARKS

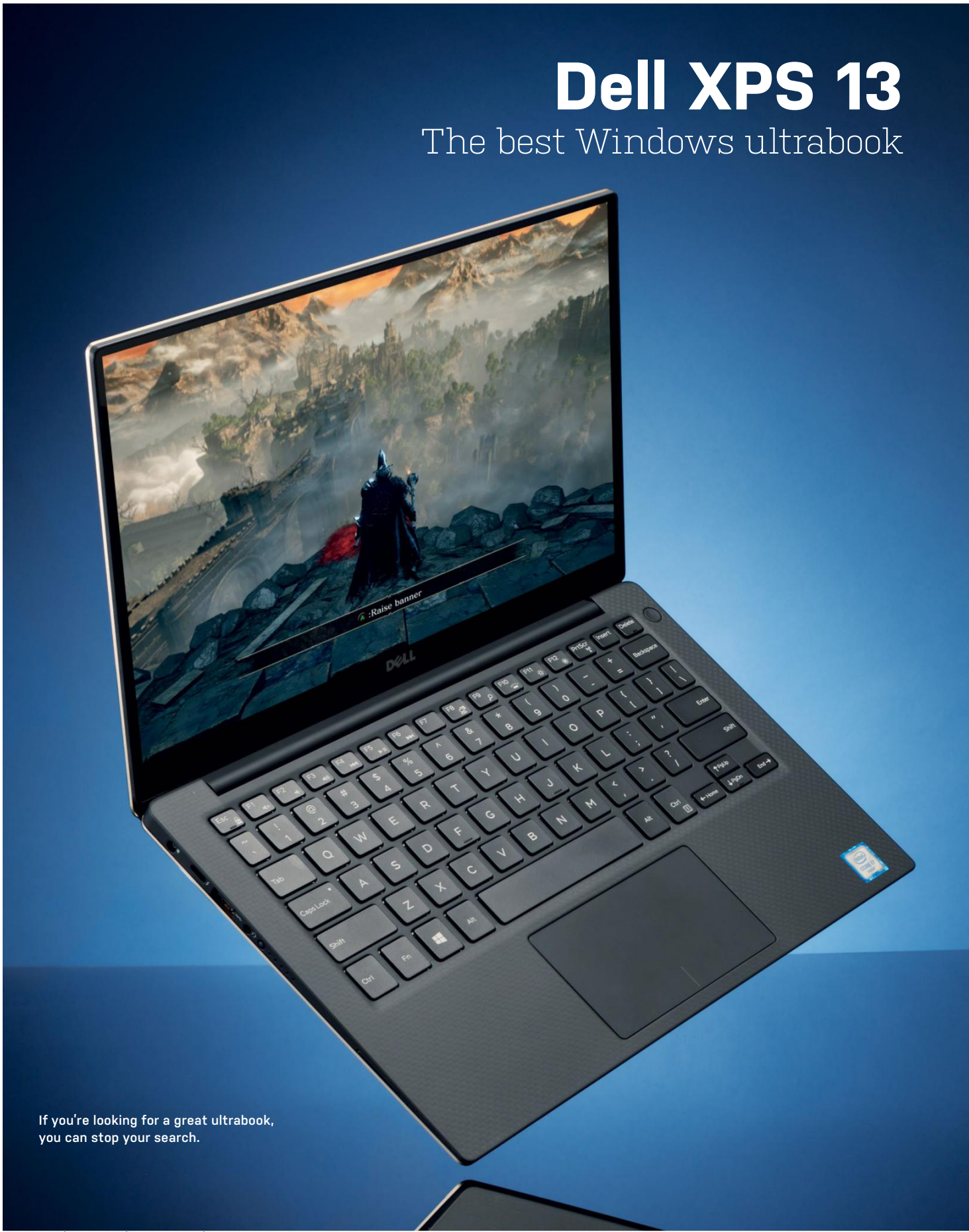
	ZERO-POINT	
Stitch.Efx 2.0 (sec)	962	542 (43.7%)
ProShow Producer 5 (sec)	1,472	1,218 (17.3%)
x264 HD 5.0 (fps)	33.8	23.2 (-31.3%)
Batman Arkham City (fps)	204	237 (16.2%)
Tomb Raider (fps)	87.5	97.6 (11.5%)
3DMark Fire Strike	8,016	8,073 (0.7%)
Shadow of Mordor (fps)	70.1	90.7 (29.3%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses an Intel Core-i7 6960X CPU, three GTX 980s, and 16GB of RAM. *Arkham City* tested at 2560x1440 max settings with PhysX off; *Tomb Raider* tested at 3840x2160 Ultimate settings; *Shadow of Mordor* at 3840x2160 max settings.

Dell XPS 13

The best Windows ultrabook



If you're looking for a great ultrabook, you can stop your search.

ULTRABOOKS have carried a stigma since their inception. Arguably, the only acceptably powerful one for a long time was Apple's MacBook Air—yes, we said that. Spec-wise, it was more powerful than any Ultrabook, especially with Apple offering PCIe SSD way before others did. But things have changed. Companies have caught on; they've realized that people want a powerful, svelte notebook, with great design and performance. And Dell has delivered just that, plus so much more.

The new XPS 13 is the smaller brother of the XPS 15, but it's certainly not smaller in terms of performance, and it also takes on the beautiful and striking design of the XPS 15. Right off the bat, you get a super-thin machine wrapped in aluminum that can compete with anything Apple has to offer. Then you open the unit and realize Dell has one up on the fruity company: the screen. The XPS 13's screen adopts the same ultra-thin bezel design seen in the XPS 15, and it sports an eye-openingly beautiful 3200x1800 IGZO panel. In case you were wondering, 3200x1800 in a 13.3-inch screen is just crazy. Windows has got substantially better at handling high-resolution displays, but it's not all-encompassing. Adobe programs, for example, still don't scale well. But hey—you get more real estate than a Columbian drug lord.

Dell hasn't let us down with other physical aspects of the XPS 13 either. The keyboard is a pleasure to use, and feels mechanical enough that you're not reaching for an external model, and for once, we can give the same praise to the trackpad. For some, the keyboard may feel soft, as do most notebook keyboards, but relative to other notebooks and ultrabooks, the XPS 13's keyboard has enough tactile response to feel good. We're also happy to report that the XPS 13's trackpad is head and shoulders above every other Windows notebook, which generally don't get trackpads right: They're usually either too sensitive or not sensitive enough; they tend not to feel good; they don't track well; and they almost always seem like an afterthought. The XPS 13's trackpad is still not quite as good as Apple's, but we never felt we needed to grab an external mouse—and that's a darn fine compliment.

THIN SIZE, BIG PERFORMANCE

It's easy to write off the Dell XPS 13 in terms of performance, due to its size, but don't let its slim design fool you. The Core i7-6500U is exceptionally fast for everyday computing. It's unlikely that you're going to be playing high-intensity games, on the XPS 13, especially not at its full native screen resolution, but for day-to-day tasks, it's got plenty of oomph.

Dell's use of Samsung's PM951 NVMe drive also helps to keep the XPS 13 feeling zippy. We're approaching the end of life for SATA-based SSDs, especially in notebooks, and thankfully so—NVMe drives, while currently not as large in capacity, absolutely destroy SATA drives when it comes to performance. Kudos to Dell for the choice of drive.

Graphics performance is acceptable. Depending on what you want to do, it may even be great. But for the most part, the 520 could use a bit more pixel-pushing power. At 3200x1800, things can sometimes slow down. The XPS 13 definitely could have used Intel's HD5500 instead of the 520, and it could have done with a bit more RAM, too. In terms of gaming performance, let's just say you'll be relegated to using low settings in most games, and playing at 1080p or less. We can't fault the XPS 13 for its gaming performance, though—it wasn't designed for gaming, after all. While you will be able to play, we think Dell wants you to use the XPS 13 for business and content conception. Unfortunately, if you're planning to take business video calls, be prepared to show your nostrils, because the webcam is positioned in the most awkward of places. Due to the thin bezel on the display, Dell was forced to use the lower-left corner of the screen for the location of the webcam.

Unflattering video chats aside, you'll be doing business all day long. The XPS 13 kept going through an entire work day with us, before begging to slurp some juice from a wall outlet. In fact, if you were to take the XPS 13 to a Starbucks, the store would close up before the battery. That's impressive. In normal use, the XPS 13 managed 12 hours and 47 minutes.

At the time of writing, the Dell XPS 13 is going for roughly $1,400 online. That's a good deal for what you get. If you care not for serious gaming, the XPS 13 is talk of the town for good looks and smarts. You get the best of the XPS 15 but in a lighter, easier-to-handle package. There's a Core i5 version with a 1080p screen and no touch, but we think the screen on this model puts the other out of consideration. **–TUAN NGUYEN**

VERDICT
9
KICK ASS!

Dell XPS 13

+ TALK OF THE TOWN Beautiful screen; fast storage; excellent battery life; priced well.

– DIRTY RUMORS Not for gamers; small storage; awkward webcam placement.

$1,400, www.dell.com

SPECIFICATIONS

CPU	Intel Core i7-6500U
RAM	2x 4GB LPDDR3 1,867MHz
GPU	Intel HD Graphics 520
Display	13.3-inch, 3200x1800 IGZO multitouch
Storage	Samsung PM951 NVMe MZ-VLV256D 256GB
Connectivity	1x USB 3.1 Type C with Thunderbolt 3, 802.11ac, SD reader, 2x USB 3.0, Bluetooth 4.0
Dimensions	11.98 x 7.88 x 0.6 inches
Weight	2.7 lb

BENCHMARKS

	ZERO-POINT	
Stitch.Efx 2.0 (sec)	962	978 (-1.7%)
ProShow Producer 5 (sec)	1,629	1,783 (-9.5%)
x264 HD 5.0 2nd (fps)	13.5	13.0 (-3.7%)
BioShock Infinite 1080p DX11+Ultra (fps)	36.1	7.1 (-80.3%)
Metro: LL 1080p "Normal" (fps)	30.4	21.3 (-29.9%)
3DMark 11 Performance	4,170	4,954 (18.8%)
Battery Life (1080p Video, mins)	234	282 (20.5%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point notebook is an Alienware 14 with a 2.4GHz Intel Core i7-4700MQ, 16GB DDR3-1600, 256GB mSATA SSD, 750GB 5,400rpm HDD, GeForce GTX 765M, and Windows 7 Home Premium 64-bit. *BioShock Infinite* tested at 1920x1080 at Ultra DX11 settings; *Metro: Last Light* tested at 1920x1080 at DX11 medium quality settings, with PhysX disabled.

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Logitech G900 Chaos Spectrum

Nailing that wireless conundrum

LOGITECH'S G900 Chaos Spectrum seeks to innovate in one of the most difficult markets to master—that of the wireless gaming mouse. Long despised by true gamers, wireless mice have earned themselves a reputation fraught with woe. Whether that's jitter bugs, interference issues, sluggish battery life and charging methods, or a clunky design, there's always been something to put off gamers on the hunt for a truly cable-free experience. Can Logitech shake off the brutal dogma attached to wireless mice? Is this Chaos Spectrum enough to finally decimate the wireless competition?

Unboxing the G900 is a messy affair. Removing the outer sleeve and opening the single-hinged container, you're greeted with a plethora of angled cardboard shapes; shapes that look more akin to desktop wallpaper than something designed to protect the intricacies of your new, meticulously crafted, pinpoint-precision machine. Still, the G900 will gleam up at you, sitting there in its simplicity, ready to play. Removing the mouse and then the bottom packaging reveals the optional secure lock Micro USB cable—for those battery-less moments you're caught short—and the wireless dongle housing, which also serves as a USB pass-through if you do intend to use the cable more long-term, and need a little extra length. The wireless 2.4GHz-capable dongle is minuscule in comparison to the rest of the setup. Plugged into a keyboard's USB pass-through, it's hardly noticeable, making it a bit of a nuisance to remove.

The G900 sits comfortably in the grasp of a palm-gripper, reassuringly supporting your, well, palm, and protecting your pinkies from drag and discomfort. It almost feels like it's angling your hand upward, certainly compared to something like a SteelSeries Sensei or a Rival, as the angle falling off the back of the Chaos is far deeper than that of its competitors. But this isn't a negative; interestingly, it makes it incredibly easy for those used to palming to swap to a more claw-like grip if need be—perhaps you've got a painful case of hand cramp today.

LED BATTERY EATERS

What's intriguing about this particular rendition of wireless depravity stems from Logitech's Gaming Software, which is how the Spectrum manages that mighty 500mAh battery sitting in its guts. In short, there's a lovely little battery tab on the bottom row of the software. What's particularly interesting here—and somewhat a rather obvious inclusion in our opinion; seriously, why doesn't everyone do this?—is that it shows you how much battery life you have left, calculated in both percentage and hours. The thing is, it also contains four different settings for lighting presets: "Color Cycle," "Cyan Breathing," "Lights Off," and "My Setting," all of which affect how much predicted battery life you have left. For instance, at 45 percent, "Color Cycle" nets us 11 hours of estimated usage. However, if we were to go to "Lights Off," we gain an additional three hours of battery life. Yep, those two tiny LEDs, which you rarely see when your palm hits the metal, eat up almost a third of the overall battery life. And if that's the case for the Chaos Spectrum, you can bet your ass it's the same for other wireless peripherals—looking at you, headsets.

All RGB lighting aside, the G900 Chaos Spectrum is a stunning peripheral. The unlockable middle mouse wheel for continuous scrolling is a dream, the additional buttons useful, the comfort great, battery life good, and utility excellent. On top of that, it's impressively light—questionably so, considering it's still lugging around that 500mAh battery internally. Precision is great, and using it over a lengthy time—one working week—we haven't come up with any problems. There's absolutely zero jitter or wireless anomalies from this 2.4GHz beauty, certainly in our testing, and on top of that, the huge number of features gracing Logitech's Gaming Software is more than enough to keep even the most ardent esports lover happy. **–ZAK STOREY**

VERDICT 9

Logitech G900 Chaos Spectrum

+ CHAOS DAEMONS Hugely versatile; incredibly comfortable; lightweight; reasonably priced; strong software suite.

– CHAOS EMERALDS Still a wireless mouse; a bit plasticky.

$150, www.gaming.logitech.com

SPECIFICATIONS

Sensor	Pixart Technologies PMW3366 Optical Sensor
Polling Rate	125Hz, 250Hz, 500Hz, 1,000Hz
Max Sensitivity	12,000 dpi
Programmable Buttons	11
Weight	3.8oz

Red, white, black? Take your pick.

Munro Sonic Egg 100

Two thousand bucks of pure awesomeness

FOR THE LONGEST TIME, speakers have been one of the most misjudged items any computer enthusiast can purchase. We're sure you all remember the days of those god-awful $20 plug-in 2.0 Logitech speakers from way back when. That tiny plastic shroud housing the tinny sounding dynamic drivers littered within—great for playing *Half-Life 2* or jamming along to some substandard MP3s, but they leave a lot to be desired in today's environment of super-quality headsets and high-resolution audio.

As you can probably tell from the amount we've been covering it, audio has had a resurgence in recent years; higher quality files, better-sounding DACs, and far superior headphones now litter the market. But where does that leave speaker-lovers? Those not bothered by family, neighboring apartments, or any other inhibiting factors, freeing your cranium from those troublesome ear-huggers?

This leads us to one option, one that is more often than not chosen by the likes of professionals, those sitting in front of their Apple Macs, recording tunes from talented musicians littered across the country. Studio monitors—relatively inexpensive, you can pick up a pair for less than $150 if you look in the right places, but a good set can set you back anything up to $3,000 and beyond. So, what do we have here? Munro Sonic's Egg 100s—$2,000 of beautifully crafted perfection. For the price, you get two lovely egg-shaped passive monitor speakers, rigid and resonant-neutral, each featuring a 25mm tweeter for your high trebles, and a 100mm driver for your low mids and basal tones. Curvaceously designed to minimize noise resonance from any straight lines and edges internally.

SOME ASSEMBLY REQUIRED

Straight out of the box, you're going to need a solid DAC to plug these babies into, because the only inputs located in the back of the external amplifier unit are two XLR connections. Even in the office, we had to borrow a more premium DAC from the guys at *Music Radar,* just to get these bad boys working. We then tested the difference between a standard XLR-to-XLR connection and an XLR-to-RCA cable, just to ensure that those utilizing a more traditional PC-enthusiast DAC wouldn't be penalized for it. And, sure enough, there was zero noticeable difference.

Going back to the amplifier, it's a stunningly crafted aluminum box featuring a separate snazzy headphone amplifier. That may seem like an antiquated decision, compared to integrating it into the monitors themselves, but having access to the volume control externally, as opposed to on the back of the speakers, is a gift.

Setting up the two monitors is fairly painless, too—the cable connections are secure, and both speakers sit on two well-designed rubber mounts, enabling you to position the Egg 100s at any angle you feel is necessary to maximize your aural experience.

As far as sound quality goes, the Egg 100s are exceptional. They're crisp and beautifully well balanced, with an incredibly vast soundscape. The bass is well rounded and intuitively pronounced in more synthetic or electronic musical styles. Of course, some of this may depend on what DAC you're taking advantage of. In our case, we were still utilizing our trusty Denon DA-300USB. When it came to more mainstream genres, you could really hear the higher production values—the music was simply incredible to listen to. Moving on to more acoustic genres and the classical style of sound, there was a serene beauty to it all. There's something about hearing the mistakes that the artists make; the clink as the plectrum hits the strings, the bite as those vocal chords pronounce the Ts, so crucial to good songcraft. They were hugely warm. Epic score was hair-tingling, orchestral arrangements felt alive and powerful—enough to make even the most stoic of hearts take a step back for a second. It was constantly enjoyable, unlike anything we've ever experienced.

So what are the downsides? Well, space is going to be a huge concern. Keeping the amplifier external—although a stroke of genius in some respects—may cause trouble for those lacking a larger desk, and the monitors themselves are far larger than anything you'd see from the amateurish 2.1 speaker systems of yesteryear. But then they need to be to fully encapsulate that sound. On top of that, they're not cheap—$2,000 is a significant chunk of money. Yet, again, if you're in the market for a professional audio system, you're more than likely going to be looking at spending more than that anyway. Price aside, in our eyes, the Munro Sonic Egg 100s are damn near perfect. **–ZAK STOREY**

VERDICT **9** KICK ASS!

Munro Sonic Egg 100

+ EGGCEPTIONAL Incredible sound quality; powerful volume; 120W amplifier; integrated headphone amp; intuitive design; lightweight.

– EGGCRUTIATING Size; price; need a DAC.

$1,999, www.munrosonic.com

SPECIFICATIONS

Tweeter and Driver Size	25mm and 100mm
Effective Internal Volume	14l
HF Unit Sensitivity	95dB SPL for 1W at 1m
LF Unit Sensitivity	86dB SPL for 1W at 1m
Total Amplifier Wattage	120W
Speaker Dimensions	13.8 x 9.4 x 9.1 inches
Amplifier Dimensions	15.4 x 12.2 x 7.1 inches

Not as fancy as the RoG, but she's still got it where it counts.

Acer Predator XB271HU

A stunning monitor, but it isn't the only option

WE'RE GETTING THERE. We're getting mighty close to the perfect monitor. The Acer Predator XB271HU is a frankly gorgeous display, and ticks almost all the boxes for the ideal gaming monitor. But, sadly, it's turned up to the party the wrong side of fashionably late, and wearing the same outfit as the host. Though not quite as well.

Acer has got so much right with the new Predator; it's rocking a high-end-GPU-pleasing 2560x1440 native resolution, lovingly laid out on a 27-inch IPS panel. It comes sporting Nvidia's G-Sync frame synchronisation tech, and is capable of hitting a top refresh rate of a kitten-smooth 165Hz. The beefy GPU brigade may be hankering for a 4K IPS panel in there, like the Asus RoG Swift 27AQ, but we're still some way off getting one running at those silky refresh speeds.

The 27-inch screen is the perfect scale, in terms of pixel pitch, for a 1440p resolution—and, with a decent GPU, you'll be running games at the native res of the panel at speeds which will make G-Sync look its best. Though that 165Hz refresh rate is a thing to behold, too, and damn us if it isn't actually noticeably better than the ol' 144Hz panels. Don't get us wrong—144Hz monitors still look great, but you can see a boost in visual clarity when things are shifting around the screen. Running two identical panels side by side, one at 144Hz and the other at 165Hz, you can easily see the difference.

THUNDERSTRUCK

It's those two identical panels that are the problem for Acer, though. Asus beat Acer to the punch when it released the RoG Swift PG279Q earlier this year—that monitor runs the same AU Optronics AHVA panel as this Acer Predator. So Asus has stolen some of Acer's thunder by releasing its own 165Hz IPS beast, and that meant that when we turned on the Predator, we were impressed that it looked pretty much just as good, but not as blown away as we had been when running the latest Swift in.

To find a place for it, Acer has more sanded off the corners than cut them, which means it can offer the Predator for around $100 less than the RoG Swift. As a result, it doesn't look as good; the slightly weird, aggressively angular feet are a little off-putting, the controls are rather basic and unintuitive, and the screen has that faux bezel-less look, where it's recessed to the same level as the panel. We much prefer the slimline bezel of the Swift. More importantly, though, we also prefer the visuals of the Asus screen.

They're rocking identical panels; how could we prefer one over the other? AUO only delivers the panel itself to Acer and Asus; the extra electronics and calibration are polished off at the manufacturer level, and no matter what we tried with those awkward controls, we couldn't get the Predator to look quite as good as the Swift—there was something a shade yellow to the white reproduction of the Acer, and we just couldn't shift it.

But therein lies the rub; our preference for the Asus is born from testing the two cheek-by-jowl—most people are unlikely to sit these two stunning monitors together. Everyone else is just going to be too busy picking their jaws off the floor, and falling in love with the incredible clarity, color reproduction, and impressively accurate blacks they both produce, to possibly care. The marginal differences really are that small, and we really doubt anyone gaming on their Predator will shed any salty eye-juice over their experience because of anything other than enraptured awe.

When it comes down to it, the Asus RoG Swift PG279Q is the better all-round monitor. We've checked out a couple of different samples now, and have experienced none of the initial problems some users had. But the extra saving you get with the still-lovely Predator makes the decision between the two one born of cost above anything else. **–DAVE JAMES**

VERDICT **9**

Acer Predator XB271HU

PREDATOR Great image quality; slick refresh rate; reasonable price.

PREY Not quite as good as the Swift; awkward controls; ugly, angular chassis.

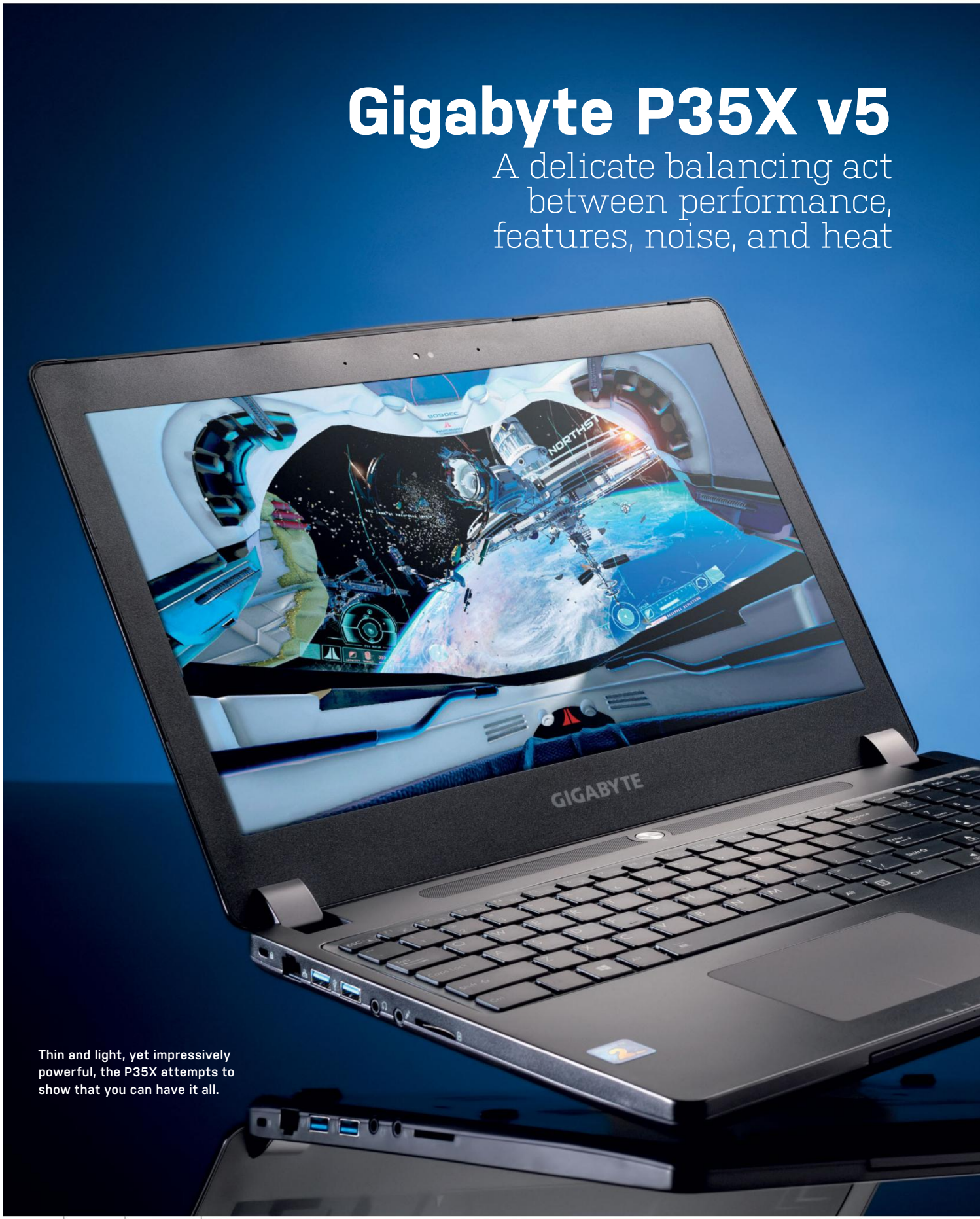
$750, www.acer.com

SPECIFICATIONS

Panel Size	27-inch
Native Resolution	2560x1440
Panel Type	IPS, 8-bit
Max Refresh Rate	165Hz
Response Time	4ms
Contrast	1000:1
Inputs	HDMI 1.4, DisplayPort
Warranty	3 years, limited

Gigabyte P35X v5

A delicate balancing act between performance, features, noise, and heat



Thin and light, yet impressively powerful, the P35X attempts to show that you can have it all.

FOR YEARS, the gaming notebook arena was dominated by large and bulky systems that performed well, but were an albatross around your neck when you had to lug them about. Razer's Blade line changed that, packing gaming hardware into a very sexy chassis. Now Gigabyte has upped the ante by including a GTX 980M instead of the slightly less potent GTX 970M.

The result is almost a gaming laptop rather than a gaming notebook, though you probably don't want to game with it on your lap. All that performance in a 21mm thick chassis that weighs just over 5lb means it can get toasty under load—we measured surface hot spots in excess of 60°C while gaming, though mostly at the back-middle (near the power button), where you're not as likely to come into direct contact. The added size compared to last month's P34W v5 also allowed it to pass torture testing, albeit at a very audible 47dB.

If that were the only thing going on, the P35X would be a good option, but Gigabyte includes plenty of other high-end features. The display is a 4K IPS panel, and while that's too much for the GPU at high/ultra settings, on a 15.6-inch display, there's no arguing it looks crisp. There's also a 256GB SM951 NVMe drive, a 1TB hard drive, and a 75.8Wh battery. Oh, and for all you holdouts who like physical media, they've even stuffed in a swappable storage bay; our unit had a Blu-ray combo drive, but it can be used for another 2.5-inch HDD/SSD.

BEAST OR BEAUTY?

When it comes to performance, the P35X v5 doesn't disappoint—from storage tests to CPU performance to gaming, it handles everything as well as you would expect. The GTX 980M is about 20 percent faster than a GTX 970M, and battery life remains a respectable four hours, beating the recent MSI GE62 and Asus G752VT by well over 50 percent in our rundown testing. And how about that modern SSD? It's typically two-to-three times the performance of a SATA drive, reaching 2,254/1,249MB/s in sequential transfers.

So far, there's not a single compromise made with the P35X v5, but we haven't covered some of the more subjective areas. In terms of styling, the P35X is either a welcome break from the garish gaming notebooks, or it's rather drab-looking. Compared to the Razer Blade 14, it's nowhere near as sexy, and the casing is mostly plastic instead of machined aluminum. Keyboard backlighting is white LED only, and the keyboard itself is a little softer than we like. The touchpad is somewhat lacking, too, with integrated buttons that don't always respond well to clicks. Also, that 4K display isn't G-Sync enabled, so while, in theory, you can play some games at 4K (typically at lower quality settings), in practice you'll mostly end up running them at 1080p.

None of these are major issues, though, and as an entire package, the P35X v5 is well rounded. The price is competitive, too, and the feature set is excellent—it's amazing to see a thin chassis with all this performance that still elects to include a swappable drive bay. Some of these compromises are a forced choice, as well: You can't have G-Sync with Optimus, so you either get G-Sync or improved battery life. And that's what it boils down to: choice. We like the P35X v5, and for some users, it's going to be a better gaming laptop than a bigger option from Asus or MSI. Others will want the sex appeal of the Razer Blade. But if you're looking for something with a bit more performance without added weight, the P35X is impressive. **–JARRED WALTON**

VERDICT **9**

Gigabyte P35X v5

HOT POTATO Impressive performance in a compact size; nice 4K display; subdued styling; good battery life.

HOT POCKET Can get hot and noisy under load; mostly plastic chassis.

$1,699, www.gigabyte.us

SPECIFICATIONS

CPU	Intel Core i7-6700HQ
RAM	2x 8GB DDR4-2133
GPU	GeForce GTX 980M 8GB
Display	15.6-inch, 3840x2160 Matte IPS
Storage	256GB Samsung SM951 NVMe, 1TB HGST 7,200rpm HDD, BD-Combo
Connectivity	Mini-DP, HDMI, VGA, Ethernet, SD reader, 3x USB 3.0 (1x charging), 1x USB 3.1 Type-C, 802.11ac Wi-Fi, Bluetooth 4.0, SDXC, 2x audio
Dimensions	15.16 x 10.63 x 0.82 inches
Weight (Lap/Carry)	5.28/6.69lb

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multithreaded	682	677 (-0.7%)
x264 HD 5.0 2nd Pass (fps)	15.2	15.1 (-0.7%)
PCMark 8 Creative (index)	6,180	6,336 (2.5%)
CrystalDiskMark write (MB/s)	112	1,249 (1,015.2%)
Shadow of Mordor	52.6	64.9 (23.4%)
Fallout 4	44	63.4 (44.1%)
3DMark Fire Strike (index)	6,583	8,311 (26.2%)
Battery Life (1080p video, mins)	142	243 (71.1%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point was an Asus G752VT with a Core i7-6700HQ, 16GB DDR4-2133, 128GB PM951 NVMe SSD, GeForce GTX 970M, and Windows 10 64-bit. *Fallout 4* and *Shadow of Mordor* tested at 1920x1080 at Ultra settings.

Astro A40 TR + Mixamp Pro TR

A gaming headset for the sociable among you

GAMING HEADSETS are funny things. Nothing beats a room full of speakers, especially for surround effects and bass, but often it's just not possible, thanks to inconsiderate sleeping relatives, noise abatement orders, or because you're playing games in the office. In these situations, a headset makes a lot of sense, and they've improved greatly in recent years, offering noise cancelation and various flavors of surround sound. Built-in mic booms enhance your trash-talking abilities, and you'll need a separate gaming headset from the headphones you use to listen to music, because what is the purpose of life other than to accumulate more stuff?

There is one other context in which a headset is essential, although fewer gamers experience it these days, thanks to high-speed Internet connections: the LAN party or tournament. The rise of pro gaming and esports has made the latter more common, and the Astro A40 is precisely targeted at those who get their kicks from public displays of annihilation.

This is some high-end gear, as evidenced by the box it comes in. Shiny and black, it weighs a ton, and hinges open in an unequal split to reveal the headset in the larger half, and the Mixamp Pro—essentially a USB soundcard—in the smaller. The mic boom and cables are hidden behind a flap on the right, and it really does come with all the cables you'd need—no fumbling for that dusty box of leads you keep under the bed.

FITTING COMFORTABLY?

The headset is comfortable, even on a large head with big hair, and the earcups fit nicely over our test set of ears. The extendable arms sport graduated markings, so you can adjust them really precisely, but we found putting them on in their longest configuration, then squeezing them down until they were most comfortable to be the best way to size them. Sometimes, the old ways really are the best.

The earphones pivot forward to lay flat against your collarbones if you want to store the headset around your neck, and the ear cushions are customizable through one of Astro's mod kits, which are sold separately. The speaker tags (the bit on the outside of the earcup opposite your ear) can be changed, too, clipping into place with magnets, and looking like an interesting project for anyone with a 3D printer and a pro gaming team. Custom designs can also be created through Astro's website.

Once you've got the headset customized to your specifications, it's time to put it on and experience the only thing that really matters: the sound quality. Luckily, for something that costs $250, it's pretty good. Really good, in fact. Piping audio straight to the headset gets you stereo, but sending it through the Mixamp Pro box activates Dolby's headphone witchcraft to extract pseudo-positional audio from the stream. Audio is clear throughout the range, and doesn't distort when you turn it up loud. Like many gaming headsets, it's a bit bass-heavy, but this matches the booming nature of game audio, and isn't something to mark it down for.

Multiple Mixamp Pro boxes can be linked together to avoid lag and interference in your voice comms, for when hearing your buddy scream really matters (although the cable for this is only 0.5m long, so it'll take some efficient organizing), and the bundled software allows customization of inputs and outputs, as well as equalizer settings. The mic boom can be positioned on either side, and is a noise-canceling and omni-directional model.

This is a premium headset that turns in a good performance. For those times when you're just sitting at home, it's maybe a little too much, although it is supremely light and comfortable to wear for long periods. But if you take your play seriously, and are part of a pro team, there's a lot to love right here. –IAN EVENDEN

VERDICT 8

Astro A40 TR + Mixamp Pro TR

ASTRONAUT Comfortable; good sound quality; decent selection of connections.

COSMONAUT Little bit expensive; connectors can be fiddly; some cables are short.

$250, www.astrogaming.com

SPECIFICATIONS

Frequency Response	20–24,000Hz
Distortion	THD less than 0.1%
Nominal Impedance	48 Ohms
Weight w/o Cable	360g
Power Output	100dB SPL at 125Hz (80% at 0dBFS)

BlackWidow X Chroma

Any color you like, as long as it's green

THE MECHANICAL KEYBOARD market continues to be vibrant, with entries from Asus, Corsair, and all the usual suspects, as well as more leftfield brands. Razer continues its campaign to confuse the hell out of anyone looking for a keyboard, with the BlackWidow X Chroma joining the likes of the Deathstalker Expert, Deathstalker Chroma Membrane, BlackWidow Tournament Edition Essential, BlackWidow Tournament Edition Chroma, BlackWidow Ultimate Stealth, Anansi and more.

The "Chroma" in the name means it offers multi-colored lighting, which won't be on everyone's wish list. The BlackWidow X does, however, have a lighting mode that we almost approve of—a reactive system that lights keys as you press them, and leaves them lit for a few seconds, before gracefully fading them out. As ever, the best use for such a lighting system is for a discreet glow, so you can use the keyboard in less-than-adequate ambient lighting conditions. And, at least, with 16.8 million to choose from, you get to pick the color of that glow. The light passes through the letter cutouts on top of the keys, rather than spilling out around the sides, and we prefer it this way—it's much less garish. All the lighting effects are controlled from the bundled Synapse software, which we've always found to be functional and simple to use.

Razer uses its own switches these days, rather than the common Cherry MX Reds that are so common in gaming keyboard. However, having said that, this keyboard is also available equipped with Cherry MX Blues (just to confuse you further).Razer's switches are rated for 80 million presses, which should suffice for most people, and each one comes with a neat little dirtproof cap to keep gunk levels down. The key-tops come off easily, enabling you to peer at the mechanism underneath, and Razer will sell you a Mechanical Keyboard Enhancement Kit, with tiny bright green rubber grommets for you to add under them to muffle the sound. The switches' activation point is quite high, enabling a speedy user to avoid bottoming-out the key before moving on to the next, and the unmuffled click is loud and noticeable, even over speakers playing the heady symphony of a game soundtrack.

NOT YOUR TYPE?

The height of the keys will come as a surprise to anyone used to a standard membrane keyboard, and we found it tiring to type on for long periods. While this is something that would pass with use, this keyboard is built with gamers in mind, rather than typists. Holding your hand on WASD is comfortable, though you may want to add your own wrist rest. The small feet at the back are capable of altering the angle, but only in one position, and, as is often the case, their use makes the keyboard more prone to slipping across a desk, thanks to their small contact patches.

The X lacks the macro keys of the full-blown BlackWidow Chroma, which comes with Green or Orange switches, and there are a few other differences. The metal of the keyboard's frame is exposed in the X, with no plastic cover. One piece of seamless metal makes up the entire top of the unit, wrapping around the sides as well. There are no macro keys or USB/audio passthrough ports, and a single braided cord breaks out the back.

In a world where more is often looked upon as being, well, more, we applaud this smaller keyboard, with its simplicity of design and clarity of purpose. It's only $10 cheaper than its bigger brother, however, so the decision over whether you want those macro keys or not is now more agonizing than ever. **–IAN EVENDEN**

VERDICT **8**

BlackWidow X Chroma

CLICKY Streamlined design; useful lighting mode; good feel to the keys.

HICKEY Not ideal for typists; not as cheap as you might expect.

$160, www.razerzone.com

SPECIFICATIONS

Key Life	80 million strokes
Actuation Force	50g
Polling Rate	1,000Hz
Weight	1.42kg
Antighosting Rollover	10 keys

Summoning friends for help opens your game up to invasion.

Dark Souls III

Badly explained, crudely ported: best *Dark Souls* yet?

"YOU DIED." Any player of From Software's games will see those words burned into their retinas. The *Dark Souls* series has specialized in being the most hardcore action RPGs available. *Dark Souls III* is the latest in the series, and possibly the last.

Like its predecessors, *Dark Souls III* is set in a thinly-sketched world, where some of the dead come back to life. At every turn of its twisted world, once-human revenants wait to jump out, items lure you into traps, and giant abhuman or inhuman leviathans are walled away in cathedrals, castles, and caves. Oh, and you're dead, too.

Players again take the role of an undead character, doomed to never die. This time, you're the Ashen One, tasked with rekindling the fire in the new area of Lothric, by dragging back the souls of the towering Lords of Cinder, who first kindled it, to the Firelink Shrine. Which means killing them and anyone else who stands in your way. That's an unusually straightforward mission for a *Dark Souls* game.

Despite subtle plot hints, the game has little more story than that—the writing is more targeted at creating atmosphere than explaining anything. Miss the opening cut-scene and you're likely to be completely lost. For most of the game, you're just exploring the world, trying to avoid dying, and finding the few routes through.

For example, one of the bosses is called the Curse-Rotted Greatwood. You don't know it's anything except an ugly, giant tree until you step too close to it and it comes to life. Once it's finally dead, if you scour item descriptions, you might get the impression that the villagers diverted their curses on to the tree, causing it to come alive—but that's the entire context for its existence.

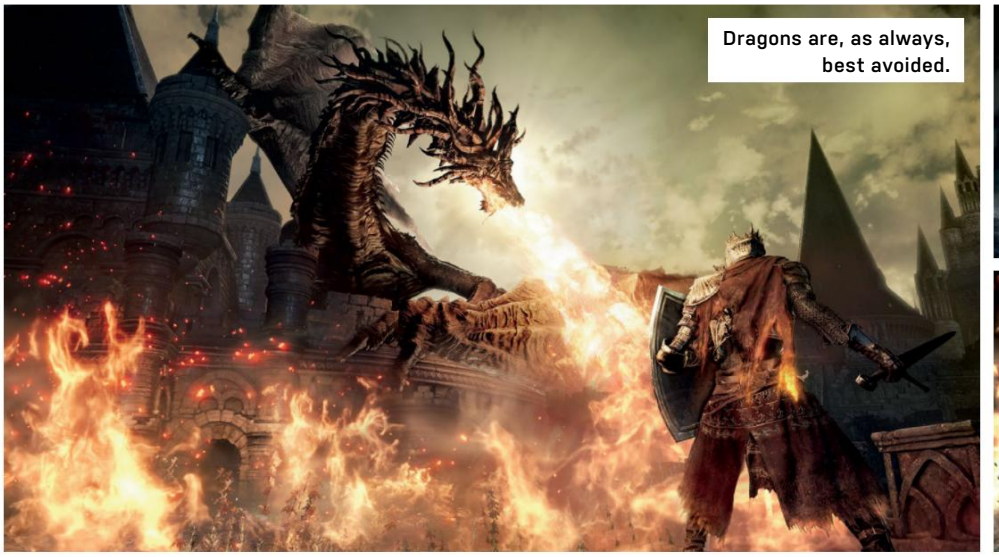
Not that this game needs a clear story—it just needs atmosphere to support its unparalleled exploration experience. The core loops haven't changed from previous games, leaving them impressively hardcore, and they throw up enough stories.

Every step is a gamble. You know that you need to be ready to defend, charge, or flee, all the time. You know that the folds of the landscape contain traps and rewards in equal measure, that no matter how lowly the creature, it can kill you in seconds, that sometimes you just will die, despite all your preparations. You also know that you need to make it to the next bonfire checkpoint before you die, else the enemies will respawn, and you'll need to do it all again.

That's made complex by the combat being so unforgiving. Enemies are aggressive, and if their attacks connect, you'll die quickly. Your choices are to dodge, block, or run—all of which use your character's limited stamina up, as do attacks, meaning even a short combat is about careful resource management, to get your character into a position where he can fight back.

That counts double for boss fights, which are much longer, and typically involve two or more stages of combat. Given that there is almost never a bonfire just before a boss fight, you often stumble into a big battle badly injured, low on crucial Estus health potions, with no idea how to survive the boss's long-range, high-damage attacks.

And when you die, there are new gambles to be made. Your souls—the game's only form of currency, used for leveling up,


Dragons are, as always, best avoided.


Stay close to this boss for a quick victory.


Sometimes it just pays to run away.


Enemy knights are often the hardest targets.


Dual-wielding is effective against slower foes.

upgrades, and buying items—are left where you die. So you've got to make it back there, wherever it is, beyond all the enemies that were reborn at the moment of your demise. Then decide whether to make the gamble again, or retrace your steps to a bonfire to cash in your souls at the Firelink Shrine.

TRACING THE BLOODLINE

Between the last *Dark Souls* and this one, From Software released the PlayStation-exclusive *Bloodborne,* a stellar game with familiar *Dark Souls* mechanics and a Cthulhian theme, but which focused more on dodging than blocking attacks, bizarre transforming weapons, and introduced effective ranged weapons. *Dark Souls III* has learned from that experience, and your characters move quicker than before.

However, From Software has added more variety to the weapons. Now, you can use weapon skills to attack in unique ways for each weapon—a halberd might allow you to charge at the enemy, while a broadsword gets something like an uppercut. These moves use power from a new meter—Focus points—which is also used for magic, requiring you to choose more carefully which weapon to use.

This has particularly helped ranged weapons, which had been slow and left you vulnerable to fast enemies. Now, the short bow has a special weapon skill that allows you to rapid fire, the crossbow allows you to push back enemies who get too close, and the longbow and greatbows penetrate through enemy defenses. These are finally viable options as you level up.

That doesn't mean the game is much easier—far from it. The later bosses, ready to seize on every mistimed dodge, were well beyond the capabilities of my aged fingers. The wider world, of cathedrals, woods, and swamps, is packed with stronger enemies. At least the landscape—beautiful, complex, and weirdly laid-out—draws you on to its looming castles and tumbledown towns.

Like all of From Software's titles, *Dark Souls III* has its flaws. It doesn't really explain its story, or how to play, particularly well. It doesn't tell you what you're meant to be doing. It doesn't give any support to weaker players. The later bosses all start to get a bit similar (giant knights with outrageous combos and reach). And the PC version is, as ever, the most unstable, with network problems, and repeated crashes for users running it on higher settings.

Criticisms aside, this is still the most accessible *Dark Souls* yet. The story, combat, and systems have been streamlined to make you focus on the most important element: surviving against the odds in its twisted world. Even then, you'll die, die, and die again—happily. –DAN GRILIOPOULOS

VERDICT 8

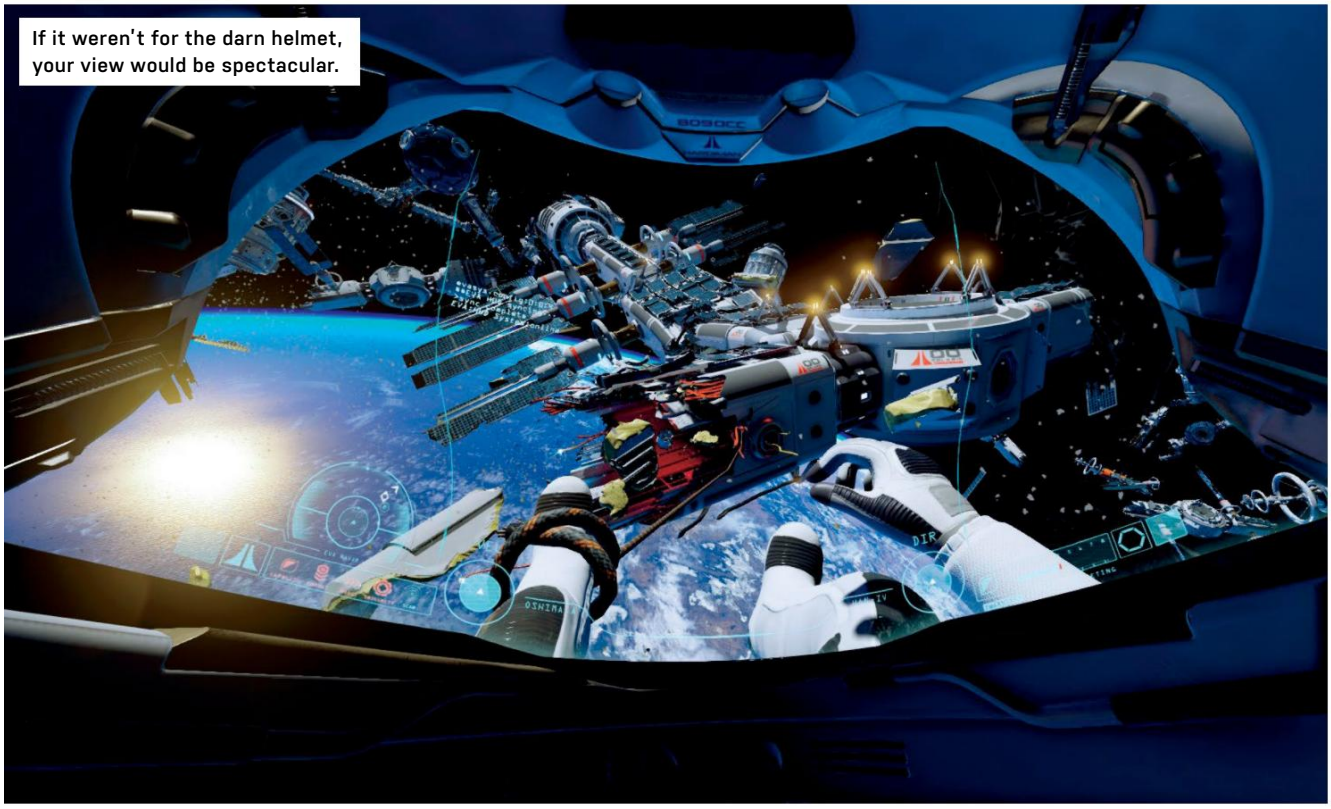
Dark Souls III

ENLIGHTENED The perfect core loop; exceptionally tough combat; beautiful, unusual, hostile world.

SHADED PC version issues; linear, thin story; unfriendly to new players.

RECOMMENDED SPECS Intel Core i7-3770 or AMD FX-8350; GeForce GTX 970 or Radeon R9; 8GB RAM; 25GB storage.

$60, www.darksouls3.com, ESRB: M



If it weren't for the darn helmet, your view would be spectacular.

Adr1ft

Imagine *Gravity* as a game, but with lots of helmet

THIS IS ODD. A game that seems like it's going to be very much like the movie *Gravity* manages to look amazing, and exhibits stunning environmental design that makes the most of its zero-gravity setting, but it's robbed of all drama and tension with a mechanic that was surely intended to do the opposite.

First, that name. The numeric interloper, likely put there for SEO reasons, draws attention to the second syllable. It's clear what the developers are aiming at, and this is one of the first games we've played that's so clearly built with VR in mind.

Should you not have your helmet in your hands right now, you'll have to make do with playing *Adr1ft* on a monitor, and that's where one design choice lets it down.

Set in the near future, *Adr1ft's* Chinese space agency has yet to invent the bubble helmet we're so used to seeing in sci-fi. Instead, something like a ship's cockpit from *Elite Dangerous* floats in front of you, the inside of a helmet that's permanently affixed to your suit's shoulders, and within which your head can move to give you a view of... the inside of the helmet. Unlike in *Elite*, this gives you no useful information, and adds nothing to the experience. It fills up a good third of the screen, leaving you peering at the outside world. And what an outside world it is. Here is a 3D space floating in space that requires you to navigate its 3D spaces after your space station is destroyed. So far, so *Gravity*. You are left floating through this glorious environment in a leaky spacesuit, but we were left wishing we could have experienced the disaster that left us in such dire straits.

That leaky spacesuit is the only thing keeping you alive, and it uses oxygen not just to keep your lungs working, but also as a propellant. With a depleting supply, much of the game is taken up with locating and catching oxygen cylinders that have been left floating by the accident, lining yourself up so as to use as little propellant as possible. They're elusive, though—your arms are surprisingly small compared to your gigantic helmet—and missing one when your oxygen level is low makes your heart sink and your lungs explode. Worse is that the death animation, once begun, overrides everything, so an oxygen cylinder can be in your hands, on its way to the valve to impart lifesaving gas, but you'll still die.

You can upgrade your oxygen storage later so the need to grab cylinders becomes less urgent, but early on, it can get tiresome. Imagined, graceful, *Portal*-like arcs, in which you use a single spurt of propellant to grab a cylinder and make it to the next door become a series of short maneuvers that see you overshoot the cylinder, go back for it, then run out of air in the next room.

In VR, this could be magnificent, and even on a monitor, the tension, constant bending of perspective in zero-G maneuvers, and the feeling of claustrophobia and loneliness make it a unique experience. The constant presence of Earth as a backdrop makes it clear what you're fighting to return to, and the ease of death makes *Adr1ft* as much a survival game as it is a floating simulator.

When VR is more common, games like this could be some of the best experiences you can have in a helmet. Right now, it's arrived to the party a bit early. **–IAN EVENDEN**

VERDICT 6

Adr1ft

+ GRAVITY Wonderful-looking; evocative; memorable.

– TRAGEDY Can be frustrating; lacks drama; some questionable design choices.

RECOMMENDED SPECS Intel i5 4570 @ 3.2GHz or AMD Phenom II 945 @ 3.0GHz; 16GB RAM; Nvidia GTX 970 or AMD R9 290.

$20, www.adr1ft.com, ESRB: T

Glowing ghosts act out scenes in residents' lives.

Sunrise over Yaughton.

Action at the bus stop.

So English it hurts.

Everybody's Gone to the Rapture

Sorry, *BioShock* fans, it's not that Rapture...

WELCOME TO YAUGHTON, population: you. This exploration game from the makers of *Dear Esther* was a hit on PlayStation 4 last year, and we feared it would never make its way to our greener-grassed side of the fence, thanks to funding and co-development from Sony. But one sudden announcement later, and here we are.

Yaughton is a village in England, blessed with bucolic charm, a splendid observatory, and a population obsessed with stargazing, as well as the usual concerns of country folk, such as extramarital affairs and escaping a flu epidemic. The year is 1984, it's apparently June, and just after 6am something mysterious happens that causes everyone to vanish. You're still there, though, along with some weird floating balls. You may well be a weird floating ball yourself, as you have no visible legs (although you make audible footsteps), and only appear to be as tall as a stalk of wheat.

The balls provide the direction you need to progress. Follow a golden will-o'-the-wisp, and ghostly vignettes play out, providing clues to what happened, along with the non-linear stories of the locals, with a scientist from the observatory as a major character throughout. You never quite know when they'll occur, although visual distortion acts as a clue, and while some start of their own accord, others must be tuned into, using the mouse or right analog stick. The latter type are especially valuable, as their conclusions are the only time the game will save—an annoying hangover from the PlayStation roots.

The scenes are well written and perfectly voice-acted, and are supplemented by further "audio logs" provided by radios and ringing phones. But there's another star that rises higher and shines more brightly—the soundtrack. By turns orchestral and choral, it's already won a BAFTA.

The game's look also deserves praise. Reminiscent of *The Vanishing of Ethan Carter*, the atmospheric forests, trickling water, fluttering insects, swaying flowers, and thatched cottages give a sense of an English village in much the same way Kazuo Ishiguro's *The Remains of the Day* conjures up an English country house. At 1080p and maximum settings, we got a little chug out of a GTX 970, but nothing too offensive.

In a game that's so detailed, the finer points matter, and things such as computers plugged into neither screens nor the wall, the gas station with very modern grades of fuel on sale, or the oddly large soccer balls and teacups, can jerk you out of the fiction. This is a shame, as it's a game that deserves to be wallowed in, and—like the starlight so many of its characters like to capture—thoroughly absorbed. –IAN EVENDEN

VERDICT 9

Everybody's Gone to the Rapture

RAPTUROUS Lovely to look at; amazing soundtrack; excellent voice-acting.

SCABROUS Moves pretty slowly; save system is annoying.

RECOMMENDED SPECS 3.1GHz Intel Core i7-4770S or 3.5GHz AMD FX-8320; 8GB RAM, Nvidia GeForce GTX 770 or AMD Radeon HD 7970.

$19.99, www.thechineseroom.co.uk, ESRB: M

LAB NOTES

ALAN DEXTER, EXECUTIVE EDITOR

Making New Marks On the Bench

Always planning for a better tomorrow

THERE ARE LOTS of conversations that happen behind the scenes that generally don't make it into the magazine. Some of these are about future products (that we can't talk about for legal reasons), while others are to do with the direction of the magazine and which tools we should use. Benchmarking, as a topic, is something that we talk about almost constantly—not quite every day, but not far off. If we're not bullying systems into divulging an actual figure, we're trying to work out which benchmarks we should retire, and which new ones are worth looking at seriously.

The point of any benchmark is, of course, to help the reviewer ascertain whether the object being reviewed is good or not. Or in the case of the monthly Build It, whether the system is actually working or not. Benchmarks are pretty good at bringing an overzealously overclocked system to its knees, too, which can make for interesting conversations with the system builder. They're good for spotting problems as well, because we know when a figure is off the pace, and can try to track down what's really happening.

We're currently looking at our gaming benchmarks with a mind to retiring some of the older titles. *Tomb Raider,* in particular, has served us well since release, but now that *Rise of the Tomb Raider* has been updated to include a benchmark, that's an upgrade you'll see being used in coming months. If there are particular benchmarks you think we should use, though, drop us a line: maximumpc@futurenet.com.

One last point: There's a reason we use publicly available benchmarks where possible—it's so that you can play along with us at home. If you want to know how your hardware compares to the latest and greatest releases, you can run the same benchmarks and find out. We can give you our assessment of a new graphics card, for instance, but knowing how your own machine compares in a game you play puts a personal perspective on things.

***Rise of the Tomb Raider*—with benchmark.**

TUAN NGUYEN

Editor-in-Chief

In search for higher quality sound from my PC, I've been experimenting with external DACs (digital-to-analog converters). DACs are essentially soundcards in a box, except they have higher quality components. More often than not, they also support higher resolution audio formats, such as 24-bit/192kHz or, in some cases, even 32-bit/384kHz. Some high-end DACs can also do DSD, or direct-stream-digital. Many DACs also act as high-quality headphone amplifiers. If you're serious about headphones, and want the best possible sound, an external DAC/headphone amp combo is the way to go. Look to spend roughly $250 or more. My favorite so far? The Woo Audio WA7d Fireflies.

ALEX CAMPBELL

Associate Editor

I've been building a bunch of PCs lately for web articles, but there are two big elephants in the room whenever I'm creating a new build: Polaris and Pascal. The big problems with building a new PC right now is that both Polaris (AMD) and Pascal (Nvidia) GPUs are getting ready for market. As such, I have to advise that some builders may want to watch prices for GPU upgrades. Furthermore, if you're looking to build a top-of-the-line, bleeding-edge, mind-blowing rig, hold off on your build until the new video cards ship. If you're looking to upgrade to a 900 series Nvidia or 300 series AMD GPU, you'll probably see prices for those components drop significantly over the next few months.

Editors' Picks:
Digital Discoveries

Jarred Walton, Senior Editor, and Zak Storey, Staff Writer, discuss their latest finds

SYNOLOGY DS415+ NAS

A few things in life are certain: death, taxes, and data loss. It doesn't matter how good technology becomes or how frequently you upgrade, at some point, your primary storage device containing important data will fail. I've only lost a few drives over my several decades in the tech field, and each one was a painful experience.

There are many ways to do backups, but one of the best options is a good NAS. The Synology DS415+ is great, with support for up to four drives (RAID 0, 1, 5, 6, and 10 supported); if you don't need four drives, the DS716+ is the two-bay alternative. You can use the software to configure automatic backups from multiple devices (Windows and OS X), and have those backups sync with other devices or upload to the cloud.

It's not just about backing up data, either. The DS415+ includes two GbE Ethernet ports with support for link aggregation and failover. It can function as a server as well, with options for mail, VPN, DHCP, and more. That's because this is basically a mini PC, with an Atom C2538 processor and 2GB RAM. Whether it's for your home or a small business, and whether you use hard drives or fast SSDs, the DS415+ is awesome. I have over half a terabyte of benchmark files, which now live on my NAS for easy access.
$600 without disks, www.synology.com

EKWB EK-TIM INDIGO XS – INTEL 115X

This issue's Build It was a special one for me. Not only was it my first venture into hardline water cooling, but it also used the chip I'd bought for my own personal build: a pre-binned 4.9GHz-capable Intel Core i7-6700K. It's a beauty, capable of running stock speeds at less than 1.1V. Cool enough, right? Well, yeah, but you can always do more. For this build, I decided to opt for something different: EKWB's Indigo XS TIM.

It's a phase-change metallic alloy (PCMA) thermal interface—a very soft metal substance. You place it between an extremely clean CPU and the heatsink, apply pressure, and attach the heatsink as usual. The next bit is trickier: the reflow procedure. You have to run an instance of Prime 95 for five minutes, with the pump disabled. The idea is to get your processor to around 85 C, and let it sit there while the PCMA melts between the two contacts. Then it's simply a case of switching off your machine for 45 minutes to an hour, and you're good to go.

Any good? Well, at idle I was registering temperatures as low as 23°C, and under load our temperatures were at 35°C. Granted, we have some meaty water cooling to back it up, but having the most efficient interface possible is certainly helping.
$28, www.ekwb.com

GEEK TESTED & APPROVED

Razer Leviathan Mini

I'LL BE HONEST, the concept of Bluetooth speakers doesn't particularly captivate me. Coming from a background of enjoying thoroughly loud guitar amplifiers, dedicated 2.1 speaker systems, and studio monitors capable of blowing your head off, the idea of grabbing a battery-powered miniature Bluetooth soundbar seems ludicrous. So it's safe to say I went into this with a pretty biased frame of mind.

As always with Razer products, unpacking the Levi Mini is a smooth experience. You're greeted by three separate compartments, the first holding your Leviathan Mini in a clear cellophane strap, surrounded by cardboard and foam padding. Lifting that, you'll find a quick-start guide, stickers, and a manual, and below that, a wee little power adapter set, including support for US and UK sockets, a gold-plated Micro USB cable, 3.5mm analog audio connection, and a velvet travel bag.

As far as sound goes, it's ridiculously impressive, especially when you consider the environment you're expected to use this in. The bass is tremendous, there's little sacrifice made to the mids, and the treble is certainly crisp enough. It can get a little distorted at higher volumes over Bluetooth, but otherwise it's nowhere near bad. Downsides? Well, there's the price to consider—$180 isn't cheap, regardless. Ultimately, it's a solid performer—just remember that this isn't a dedicated speaker system, and where you're meant to use it, and you'll be fine. **–ZS**
$180, www.razerzone.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Headphone Prices
> Unwanted Software
> Hardware Details

Sound Buy

In your headphone roundup (April 2016 issue), you listed the Kingston HyperX Cloud II Headset at $80 from www.hypergaming.com. When checking specifications on the website, I noticed the price is listed at $100. The lesser HyperX Cloud Gaming Headset is listed at $80.

Are there any headphones of this quality with a mic at $80, or will I have to beg for $20 more from someone?

–Brian Kelly

STAFF WRITER ZAK STOREY RESPONDS: Pricing changes all the time—sometimes for the better, sometimes for the worse. When we were writing the group test, the Kingston HyperX Cloud IIs were available for $80 on a special deal. Generally, in our reviews, the link is to point people toward the manufacturer's website, and the price is from the cheapest place we can find it online. It's frustrating, I know; it might make more sense to point toward the reseller, but we have limited space to include every detail, and resellers also change their prices.

If you're set on getting the Cloud IIs, they're currently available for $90 from Newegg and Amazon; $10 more but still well worth it. For value for money, they're absolutely killer. I've tested a lot of headphones in this price range, and there's very few that I've enjoyed as much as the Cloud IIs.

However, if you're after saving a touch more money, it might be worth getting the original Clouds instead; the only difference between the two is the USB dongle, and although it does play around with the EQ a tad, most of the work is done by the headphones themselves. They're about $67 currently.

Remove Bloat

Why does Microsoft (and Apple) feel the need to put applications in the OS that you have to jump through hoops to uninstall? Apps you don't use, don't want, and are taking up space you aren't willing to allocate. In Win 10, you have to go to PowerShell, find the product name, then enter an oblique command to delete it. What do they gain, aside from annoying me? Why can't they include "Uninstall" in the right-click menu? **–Steve G**

SENIOR EDITOR JARRED WALTON RESPONDS: Often, it's because the company in question wants to provide a uniform level of software in the OS, so it can always refer to that. It allows the company to say, "Sorry, we aren't the support line for XYZ; have you tried using our UVW tool?" There's also a case of feature bloat—the desire to add more value by having the OS do "more" than older systems.

Take Cortana—there are other digital assistants, but Microsoft can say, "You get Cortana for free with Windows 10!" (Or Siri with Apple's stuff.) And for most users, storage space is basically "free" these days—sure, Windows or OS X might eat up 20GB of storage, but when we're all running 1TB and larger hard drives, it doesn't matter. (It's more of a concern with 256GB SSDs, of course.)

The more nefarious point is data mining. Win10, and Cortana in particular, end up with a lot of potentially useful information about you. The more you use it, the better Microsoft can figure out how to appeal to you when it comes to advertising and such. Simply knowing the apps installed on your smartphone, it's possible to make a reasonably accurate guess as to your age, gender, race, and income bracket—it will be wrong for some, but it might be pretty close 75 percent of the time. Not every app does data mining, but when you look at the EULA for a typical OS update, there's potential for many unexpected things to happen—you gave them permission when you clicked the "Accept" button!

What apps are bothering you? Knowing that might help me understand where you're coming from. Plus, I can mine that data for other useful bits of information, so I can better target our future email exchanges. And if that sounds scary, some of the stuff happening in the world of AI and data mining would really send you scurrying for the hills. Think happy thoughts....

More Equal

I'm confused as to how you came up with the glowing review of the Kingston HyperX Cloud II headset (April 2016 issue). The reason being a glaring omission in features. I purchased this headset, and while it was comfortable, I found the sound flat for my tastes. I tried to adjust the sound, and found that all settings for this headset

↘ submit your questions to: comments@maximumpc.com

are locked, like not even having tone adjustment. I emailed Kingston, and it confirmed that all sound settings are completely locked. It said: "A possible solution to this is to develop a separate application that can grant users control of the EQ settings with the USB adapter. Now we have explored options such as this, however at this time this is not available."

Why would anyone choose a $100 gaming headset that they have to write their own software for if they want EQ adjustment, when for the same money, they can buy other headsets that include very polished software, such as the Razer Kraken 7.1 Chroma? It comes with the great Synapse software, which gives you full EQ adjustment, full surround sound configuration, bass boost, sound profiles, and more. All at the same price as the Cloud II. **–B.J. Koho**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Headsets are a personal thing. While one reviewer may think a set is too bassy, another may hold that it isn't bassy enough. It's partly down to the differences in our ears, and partly down to expectations. To be fair, the general consensus on the Kingston HyperX Cloud II is that it is an awesome headset—it isn't just us.

As for software equalizers, we avoid those like the plague, as they don't accurately reproduce the original sound as the artists intended. In fact, in order to provide as equal a field as possible, we used a pair of DACs to ensure we were comparing like for like. We're not stopping you from running a software EQ, but as we're trying to give an objective overview of headsets, we wouldn't go near them.

What really matters is that you've found a headset you like. We can point you at one that we like, but if it doesn't tick your box, you don't have to stick with it.

More Specifics

The detail and comparison boxes in *Maximum PC* that cite only Intel CPU numbers are too obscure. This is especially true for comparison boxes that mix different CPUs. We need more details to understand, quickly read, and quickly review later. I am a very long-time reader, and a system builder since 1990.

The Builds section is worthless, as CPU and motherboard numbers are obscure without research. In fact, I don't read this section anymore, as it doesn't mean anything to me unless I am buying parts that day, and then I do the research on my own. It doesn't keep me up to date on current builds.

I read and reread the articles, writing details next to the boxes. Half the time, you don't have some of the details in the article. You may have the details for each CPU in your heads, but please leave out some of the pithy comments for space to put more CPU details in a larger box. **Scott Jorgenson**

SENIOR EDITOR JARRED WALTON RESPONDS: Thanks for the feedback. We realize listing CPU model numbers alone may not be helpful if you're not up to speed on CPU names, though that's part of the point of reading *Maximum PC*. One of the best resources for finding additional details for any Intel CPU is its ARK pages, where a model number lookup provides any additional details you might need. AMD has a similar resource (not as friendly, IMO) with its Products page.

It's easy to point at one thing and say, "Leave out some of the pithy comments and put more CPU details in," but which details are important and which should we leave out? Look at any CPU on Intel's ARK pages (e.g., i7-5775C), and you will have enough data to fill an entire page in the magazine. It's a slippery slope, and for print publications, we're always going to have to cut something out. Even on the website, we're more likely to link to the ARK page for additional details rather than reproducing the entire list every time. And if CPUs are bad, motherboards are even worse.

We'd love to provide more information, benchmarks, and so on, but at some point, anyone who wants to know more will have to do the research. If you don't know that i7-4790K is a Devil's Canyon processor, which was basically an optimized version of Haswell (i7-4770K), and that the K means it's multiplier unlocked... well, we've covered that in the past, and repeating it every time we reference a model number would make for boring and redundant reading.

As for the builds, they're to get people started, and give an idea of where we currently rank items. Experienced system builders should be able to look at any build and offer several points of critique. If you're new to the PC scene, the goal is to provide a list of items you could order, put it all together, and it will all fit and work properly.

[NOW ONLINE]

CROWDFUNDING EFFORT SEEKS TO RESURRECT COMMODORE 64

The Commodore 64 holds a special place in the hearts and minds of many geeks. It's been a long time since the original C64 was in production, though. This re-imagined version of the original comes from Retro Games, a company that wants to bring back the classic computer in two forms—as a desktop model and a handheld device.

The desktop version will still come packed into a beige keyboard, but one that's less bulky than before. It will also have HDMI output, USB ports, mini-USB power socket, an audio jack, SD card slot, and a cartridge slot [wow, do you remember them—Ed].

Such fond memories for what's a fairly ugly piece of tech.

Meanwhile, the handheld version looks as though it could be the love child of an original Game Boy and the NES controller.

Read the full story at http://bit.ly/1STybkV.

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THE BUILDS

BUDGET GAMER

INGREDIENTS

PART			PRICE
Case	Cougar QBX	NEW	$55
PSU	Corsair CS550M	NEW	$80
Mobo	ASRock H170M-ITX/ac	NEW	$100
CPU	Intel Core i5-6500		$205
GPU	Sapphire Nitro Radeon R9 380	NEW	$190
RAM	8GB (2x 4GB) Kingston HyperX Fury DDR4-2133	NEW	$35
SSD	250GB Samsung 850 EVO 2.5-inch SATA	NEW	$88
HDD	1TB Seagate Barracuda 7,200rpm 3.5-inch SATA	NEW	$59
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit		$16

Approximate Price: $828

WOW, DID WE CHANGE IT UP THIS MONTH. First, we changed the case. While we love the Cooler Master Elite 110 for its small footprint and minuscule price, the Cougar offers better airflow and the ability to use longer video cards, for just $15 more. The case does limit the size of PSU you can use, though. We went with Corsair's short CS550M to make sure the PSU would fit. We also reverted to the ASRock H170M-ITX/ac, which is a fine mobo for locked CPUs. We swapped memory for something a little more low-profile—G.Skill's Ripjaws V series are great, but the heat spreaders are on the tall side. The HyperX Fury sticks are more subdued and about the same price. As for storage, we swapped the M.2 Evo for the 2.5-inch version, because the ASRock mobo doesn't support M.2. We also added a 1TB Seagate Barracuda for extra storage, which put us over the $800 mark. If you can get by with just the SSD, this rig will cost just $769.

MIDRANGE

INGREDIENTS

PART			PRICE
Case	Phanteks Enthoo Pro M		$75
PSU	SeaSonic G-Series SSR650RM 650W	NEW	$95
Mobo	Asus Z170-A		$140
CPU	Intel Core i5-6600K		$245
Cooler	Corsair H80i v2		$87
GPU	EVGA GeForce GTX 980 SC ACX 2.0	NEW	$500
RAM	16GB (2x 8GB) Corsair Vengeance LPX DDR4 2400		$60
SSD	250GB Samsung 850 EVO M.2	NEW	$94
HDD	Western Digital Black Series 1TB 7,200rpm	NEW	$74
OS	Windows 10 Home (*Download*)		$110

Approximate Price: $1,480

THIS MONTH'S MIDRANGE makes a change from last month's: We went back to the GTX 980 to push our pixels. Prices for the 980 have fallen slightly, and some models, such as this EVGA ACX 2.0 superclocked model, are as low as $500. This may be due to price pressure from the R9 Nano, or the attempt to move units while people hold out for Pascal. Either way, we're likely to see some more price slippage for the 980. To accommodate the move to the GTX 980, we had to make some savings somewhere. We dropped our SSD capacity from 500GB to 250GB, and dropped our HDD capacity by half, as well. We also swapped out our EVA PSU for a SeaSonic. The SeaSonic is a high-quality 80 Plus Gold-certified PSU that comes with a five-year warranty. We stayed with the Core i5-6600K, which saw a small price drop. We've been seeing prices for the K-model Skylake processors start to settle, since demand had been pushing things out of whack.

TURBO

IF YOU DON'T LOOK AT THE VIDEO CARD VENDOR for this rig, we can see that the Turbo has remained mostly the same. But that isn't to say there aren't changes to be found. The Turbo's pair of GTX 980 Tis from Zotac ended up being $20 cheaper per card than the PNY models last month. That's a $40 saving right there for a nearly identical reference blower design. One thing of note is that the price of the Core i7-5820K shot up to $390 (yeowch!), while the price of Samsung's 950 Pro NVMe SSD dropped significantly. We were also able to absorb some of the pain from the CPU price increase by dropping the RAM clock speed from 2,666MHz down to 2,400MHz. RAM clocks are rarely the bottleneck of any modern system, and we honestly feel that we could overclock the memory a little using XMP profiles if we wanted to. Finally, we found that we overcompensated a bit in our price-cutting measures, so we added another 2TB WD Black for $122. With that second drive, we get a choice between the speed of RAID 0 or the redundancy of RAID 1. Either way, we feel that $122 is put to good use with the spinning hard drive.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART		PRICE
Case	Cooler Master MasterCase 5	$105
PSU	EVGA SuperNOVA G2 850W	$130
Mobo	MSI X99A SLI Plus	$230
CPU	Intel Core i7-5820K	$390
Cooler	Corsair H100i v2	$100
GPU	2x Zotac GTX 980Ti (Reference) NEW	$1,240
RAM	32GB (4x 8GB) G.Skill Ripjaws 4 Series DDR4-2400 NEW	$125
SSD	512GB Samsung 950 Pro M.2 (NVMe)	$310
HDD	2x Western Digital Black Series 2TB 7,200rpm NEW	$244
OS	Windows 10 (*Download*)	$110

Approximate Price: $2,984

UPGRADE OF THE MONTH

EVGA GTX 980 TI VR EDITION

Of course, the GTX 980 Ti is nothing new at this point, but EVGA has made a subtle change that makes its ACX 2.0 model more attractive for virtual reality users: front panel access. That's right—the GTX 980 Ti VR Edition moves one of its HDMI ports from the back panel of the card to the "front," near the power supply connection.

This allows an HDMI passthrough cable to connect to a front panel, making connecting and disconnecting an Oculus Rift much, much easier.

$700, http://evga.com

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