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MAXIMUM PC

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- AMD and Nvidia working together

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Future

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GAMING

K70 RGB RAPIDFIRE

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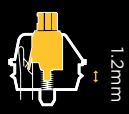
RAPIDFIRE MX SPEED
ULTRA FAST ACTUATION



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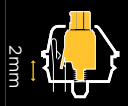

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inside

JUNE 2016

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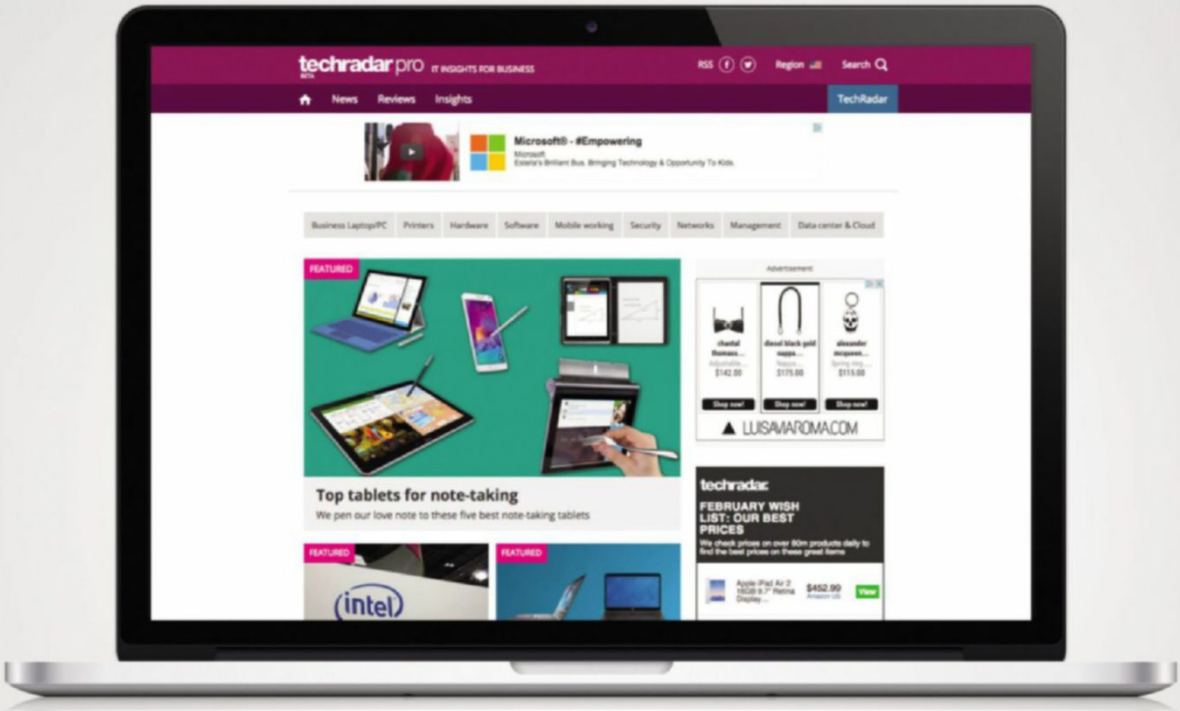

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Tuan Nguyen

THE MERGE

NORMALLY, I USE this page to talk about the exciting stuff that's in the current issue of the magazine, but I have an announcement to make: By the time you read this, MaximumPC.com will be merged with PCGamer.com.

Maximum PC has been around for over 20 years now. Starting out as the ground-breaking *boot* magazine, we've been covering PC tech and culture with an attitude ever since. With the launch of the Maximum PC website several years ago, we were able to expand our coverage of hardware significantly, and our remit is now broader than ever.

From a purely numbers point of view, the hottest topics we've covered have been graphics cards, CPUs, and other gaming-related components. Graphics hardware remains key to pushing the PC platform forward. When Nvidia introduced the world's first graphics chip with programmable shaders—the original GeForce—the world took notice. When AMD (ATI at the time) responded with its über-fast R300 GPU, it was clear that graphics for gaming was going to spearhead PC evolution.

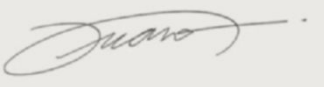
Fundamentally, games have always been the driving force behind new hardware development on the PC. In other words, enthusiasts and gamers push the envelope forward together. And as we've seen over the past two decades, building rigs and playing games go hand in hand.

I'm very excited about the marriage of the two sites. MaximumPC.com isn't perfect. PCGamer.com isn't perfect. Together, we're still not perfect, but we're better together than we are apart. We will have a larger team and more resources. More ideas and creative projects are being cooked up.

This merger doesn't have an impact on the magazine you're reading. *Maximum PC* magazine will remain independent. In fact, I can already see that more in-depth guides will come, due to the sheer size of the overall team working on both the magazines and the website. Dream Machine, of course, will live on. We're already working on Dream Machine 2016, and it should be bigger and more kick-ass than even Dream Machine 2015. Conveniently, no one claimed it, so I was fortunate enough to move it under my desk for "work."

I do understand that not all MaximumPC.com readers are interested in games. We will still cover the same hardware and industry news. A large portion of the topics do interest gamers, and many gamers are interested in non-gaming hardware. So the site merger is more of the good stuff.

Change is not to be feared. In fact, it's a key part of the PC platform. Gaming and enthusiast hardware are on the rise, and evolving faster than ever before. The advent of VR is nearly upon us, real 3D audio is coming back, and there's an ever-greater demand for high-quality components. There's no better time to be a PC owner. I hope you'll join us.



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

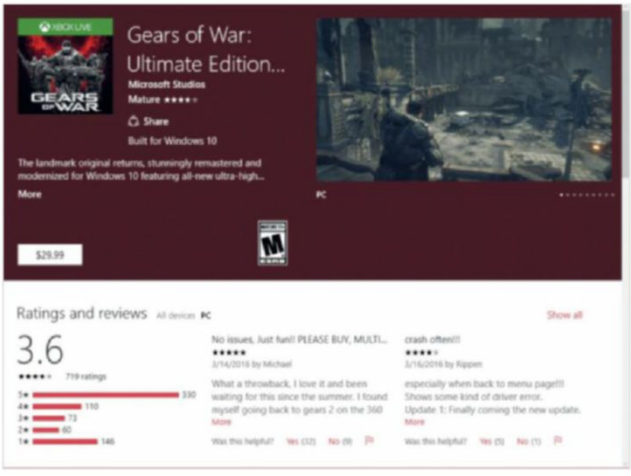
Does PC Gaming Need UWP?

Not everyone is on board with the Universal Windows Platform

MICROSOFT hasn't had an easy time getting industry bigwigs to see its vision or to share its excitement over what the future might hold. When Windows 8 came out, Valve's Gabe Newell called it a "catastrophe for everyone in the PC space." Part of his concern, as shared by several developers, was that Microsoft was creating a walled garden whereby it would have full control over apps running on its platform.

Fast-forward to today, and there's again concern about Microsoft exerting too much power, only this time it's Epic Games's Tim Sweeney who's holding Microsoft's feet to the fire. His beef isn't so much with Windows 10, but Microsoft's Universal Windows Platform (UWP) initiative. The abridged version is that Microsoft is promoting a single ecosystem for developers to create applications that can run on different devices. These are called Universal Windows Apps (UWAs), and they'll run on any Windows 10–based gadget.

In a piece for *The Guardian*, Sweeney flogged Microsoft's UWP initiative with harsh rhetoric. He called it "the most aggressive move Microsoft has ever made," and accused Microsoft of "moving against the entire PC industry," especially gamers. His denouncement was especially notable because Epic's *Gears of War: Ultimate Edition* is one of a small number of triple-A UWP games.



Part of the reason for *Gears of War's* mediocre user rating is the result of limitations in UWP, which Epic Games can do nothing about.

UWP games and apps can only be downloaded and installed from the Windows Store, where Microsoft takes a 30 percent cut. As far as Sweeney is concerned, Microsoft is "locking down the consumer PC ecosystem." On top of that, UWP lacks support for several popular features, including user mods and FPS overlays, such as Fraps.

> UWP lacks support for several popular features, including user mods.

Microsoft isn't unaware of the criticism, but insists that UWP is an open platform, telling *The Guardian* that it's "available to every developer." The company also noted that a November update made it easy for users to "side-load apps by default." So is Sweeney wrong?

"Both Tim and Microsoft are right; UWP apps are somewhat closed as it's a proprietary OS and platform, but it's open in that Microsoft says it won't restrict apps, development, or distribution," Brian Blau, Research VP, Personal Technologies: Innovation at Gartner told *Maximum PC*.

Blau went on to compare the situation with UWP to Valve's Steam platform: "Just look at the situation on PC. It's open but we know that Valve/Steam controls the majority of distribution. Sure, the PC is open, but you could say that Valve controls PC gaming, and if a developer does not want to participate in its way of doing things, they may not have the same level of success."

So, is Microsoft trying to compete with Steam? "There's no doubt Microsoft wants to become a Steam competitor. It has a track record of stumbling out of the gate and then reiterating and eventually getting it right, or at least good enough to silence the critics," Lewis Ward, IDC's Research Director for Gaming, told *Maximum PC*. "Right now, I think Microsoft should focus on getting a digital distribution platform that can compete effectively with EA's Origin. Let's not worry about tackling Valve's Steam service until the Win 10 gaming infrastructure can beat the likes of Origin and GOG." Sound advice. **–PL**

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WIN 10 CAN NOW FIGHT OFF CYBER ATTACKS

Stopping hacks in their tracks

MICROSOFT'S TERRY MYERSON announced that Windows 10 now includes Windows Defender Advanced Threat Protection. He says that this new service will help detect, investigate, and respond to advanced attacks on company networks. For you, this means your personal data should be more secure when companies switch to Windows 10 and use this new service.

According to Myerson, Windows Defender Advanced Threat Protection builds on Windows 10's existing security defenses and adds a new "post-breach layer of protection." The service combines a "robust" cloud service with Windows 10's client technology, and will supposedly detect attacks that will break through other defenses.

The new Windows 10 service will provide detailed information about what happened during an attack, including why, when, and by whom. Myerson says the service is powered by multiple ingredients: Windows behavioral sensors, threat intelligence, cloud-based security analytics, and Microsoft's own intelligent security graph.

"This immense security graph provides big-data security analytics that look across aggregate behaviors to identify anomalies—informed by anonymous information from over one billion Windows devices, 2.5 trillion indexed URLs on the web, 600 million reputation look-ups online, and over one million suspicious files detonated every day," Myerson writes.

Because this service is baked into Windows 10, customers won't have to worry about manual updates and deployments, Myerson says. There's also no ongoing maintenance or the need for an on-premise server infrastructure. Windows Defender Advanced Threat Detection also complements current Microsoft services, such as Office 365 Advanced Threat Protection. **–KP**

OPERA INJECTS AD-BLOCKING INTO ENGINE

BOLD SPEED CLAIMS

OPERA SOFTWARE BELIEVES the key to making its browser run faster is by building ad-blocking software directly into the browser's engine. That's the case with Opera's newest developer version, which the company claims is nearly twice as fast at loading web pages.

"Once enabled, the ad-blocking feature speeds up webpage load times by as much as 90 percent, compared to browsing with the option disabled," Opera Software says. "The integrated ad-blocking technology also gives, on average, a 40 percent faster browsing experience compared to third-party ad-blocking extensions."

Opera attributes the speed gain compared to third-party solutions to filtering ads at the web-engine level, where the browser has full control over the loading process. As such, there's no add-on or extension to download, though it is opt-in by way of a pop-up at the top-right of the browser. Also, users can turn the ad-blocking feature off for specific sites. **–PL**

AMD REVEALS $1,500 DUAL-GPU RADEON PRO DUO

Twice the Fury

AMD HAS ANSWERED the call for a graphics card with two GPUs based on its Fiji architecture, but the new Radeon Duo Pro isn't really intended for home consumers. Instead, AMD is taking aim at content creators focused on virtual reality games and applications.

This dual-headed beast is basically two Radeon R9 Fury X GPUs sharing real estate with one another on the same card. Each of the GPUs independently rocks 4,096 stream processors, 256 texture units, and 64 ROPs. There's also 4GB of high-bandwidth memory on a 4,096-bit bus per GPU. It's kind of a bummer that a card of this magnitude isn't sporting 8GB of memory per GPU, but that's where HBM technology is stuck at for the moment. In any event, this is still a monster card, one that AMD claims is capable of 16 TFLOPS of performance. **–PL**

Tech Tragedies and Triumphs

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

TRIUMPHS

VALVE TURNS TO MODDERS
Think you can build a better Steam Controller? Now's your chance to prove it—Valve has made the controller's CAD geometry available.

BREAKING THE SPEED LIMIT
Seagate announced plans to launch the fastest SSD ever seen. How fast? Up to 10 gigabytes per second!

A SHARPENED BLADE
Razer recently upgraded its 14-inch Blade laptop for gamers with faster hardware while making it lighter and cheaper. That's a winning trifecta.

TRAGEDIES

HUMAN CORRUPTION
In under 24 hours, Twitter users turned Microsoft's teen girl AI chatbot into a racist, hate-spewing troll.

SIGNING OFF
Email inventor Raymond Tomlinson sadly passed away at age 74. We thank him for giving us the future of communication.

UPGRADE SHENANIGANS
A mob of angry users raged against Microsoft online, claiming the Redmond outfit had upgraded their PCs to Win 10 without permission.

Dave James

TECH TALK

DirectX 12 and the Galling Multi-GPU Morass

THE PROMISE AND POTENTIAL of Explicit Multi-Adapter support from DirectX 12 has got a lot of us PC folk excited about the prospect of a multi-GPU nirvana. But while there is the potential for some sort of hippy graphics silicon love-in with Microsoft's new API, it has the equal possibility of causing more frustration than it salves.

The existence of DirectX 12's Explicit Multi-Adapter (EMA) feature shouldn't be news if you've been following Microsoft's latest API as it stutters into life. As we wait for genuine DirectX 12 games to arrive, it's tough to know exactly how powerful the new multi-GPU feature is going to be across the board, but we can still make pretty educated predictions.

EMA is Microsoft's solution to the problems of driver-based multi-GPU systems and their reliance on graphics vendors to get support right for as broad a selection of games as they can. Even now, there are games without multi-GPU support built in.

DirectX 12 treats multi-GPU systems in one of three ways. The first is Implicit Multi-Adapter (IMA), which works the same way as SLI and CrossFire do within DirectX 11. It uses the same alternate frame rendering (AFR) techniques, with each discrete GPU given alternate full frames to render on its own before being queued up to be blasted into our eyes.

The second and third ways come from that hoary ol' Explicit Multi-Adapter chestnut. In linked mode, as with IMA, you need identical GPUs, but in this case, it's because developers have almost complete control over whatever GPU resources are made available, treating them as one big graphics card, allowing them to use split frame rendering, with GPUs working together on each frame. This is potentially the most powerful way—but probably the toughest to code for— to run multi-GPUs under DX12.

> Unlinked EMA offers the tantalizing prospect of creating some monstrous AMD/Nvidia hybrid rig.

With unlinked EMA, developers don't get such low-level access to the GPU resources, but every graphics component in the system is made available, regardless of creed or color. This is potentially one of the most exciting options for DX12, because it offers a host of scenarios where PC folk can really utilize the power of their machines, and because it offers the tantalizing prospect of creating some monstrous AMD/Nvidia hybrid rig.

Being able to upgrade your graphics card to whatever delivers the best bang for your buck, while retaining your old card to offer a leg-up to your new GPU, could mean great things for the upgrade market. There's also the prospect of using the integrated graphics in your CPU, if DX12-compatible, to enhance your discrete GPU's power. It won't necessarily deliver a huge boost, but could offload post-processing duties from the discrete silicon to the integrated, for example.

That's arguably the more likely scenario for EMA delivering on its promise, as the elephant in the room is the fact that it's all down to the developers to implement the DirectX 12-specific features for EMA. And encouraging cross-platform publishers and developers to devote time and resources to supporting an infinitesimal niche of the PC gaming audience is going to be a thankless task.

For PC-specific games such as *Ashes of the Singularity,* it's worth Oxide's time to make the effort—the game would have gotten far less coverage, for a start. But for the next *Assassin's Creed,* don't expect to be able to have your Pascal and your Polaris sitting side by side in perfect pixel-pushing harmony.

This is going to make the future even more maddening for the multi-GPU faithful. They're already struggling with day one compatibility, sometimes weak support, and the feeling they're sitting on more power than is being used. With DX12, they'll know there is a way to access almost all their expensive silicon's potential, but the developers are not going to use it.

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

Alex Campbell

OPEN SOURCE

Let's Talk About Cryp-tog-ra-phy

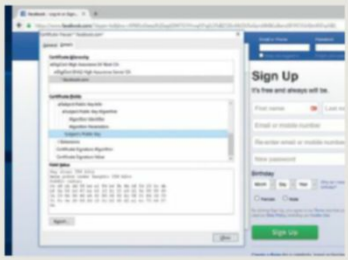
IF YOU'RE NOT A COMPUTER SCIENTIST, mathematician, or otherwise huge nerd, it can be tough to wrap your head around cryptography and why it's important. If you're just diving into the subject, it can take from an hour or two to the better part of a day just to get the basics of things like public-key encryption. And that's a problem for American society.

Nearly everyone who uses the web uses encryption, though it usually remains invisible. Log on to Facebook? You're using crypto. Amazon? Crypto. Twitter? Crypto. Google? Yep, you get the idea. All of these sites use public-key encryption and the X.509 system of certificates to prove that the machines serving up the web pages are who they say they are. (Full disclosure: maximumpc.com does not use TLS/HTTP on its public-facing web page at time of writing.) This means that even if you're not a crypto geek, don't use device encryption on your phone, or don't use PGP-encrypted email, you use crypto every day. Some people realize how important this is, while others (usually government agencies) would like to find a way around encryption technologies.

I spent a week at the RSA Conference in March, where this issue was addressed in nearly every keynote. The FBI versus Apple fight was the elephant in the room whenever a government employee or crypto expert was speaking. Whatever you think of what the FBI is asking Apple to do, the fact remains that it has brought encryption into the public eye. And that's a good thing, even if the Apple case isn't the ideal circumstance to discuss the technology.

If privacy advocates and government agencies agreed on one thing at RSA, it was that these issues have to be talked about. For years, the government has sought to weaken encryption or get companies to adopt a system of key escrow. Privacy advocates have fought back, saying that the government can't be trusted, and such compromises introduce an unacceptable amount of vulnerability to encryption systems. Mostly, the two sides have talked past one another, but this year's RSA saw them make the first attempts to talk to one another.

> Talking about encryption, privacy, and security in public, at a level that most Americans can understand, is crucial.



When you log into Facebook, you're using public-key cryptography.

Talking about encryption, privacy, and security in a public space, at a level that most Americans can understand, is crucial to the future of the technology and what we can expect out of future privacy laws. Policymakers (read: legislative representatives) are often lawyers who don't have backgrounds in computer science. This technology and its impacts have to be explained.

I spent about three hours talking to my brother (who just got his J.D. last year), explaining how encryption works, and where it is used, and how everyone—including governments—rely on it. Because he interned for a district attorney's office, we also talked about the need for law enforcement to be able to investigate crimes. I also explained to both my parents how encryption works, and that unlocking one iPhone could potentially lead to the compromise of millions of devices. It was only then that my mom and dad understood (regardless of their agreement with) Tim Cook's resistance to the FBI.

Conversations like these need to happen if we are to create laws that are agile enough to serve us in the 21st century, in the age of software, encryption, and the Internet. Not everyone will walk away from the table happy. Communication and education about the needs of privacy and law enforcement are essential to informing lawmakers and the public as they decide what the balance should be. From what we're seeing, the laws on the books just aren't good enough.

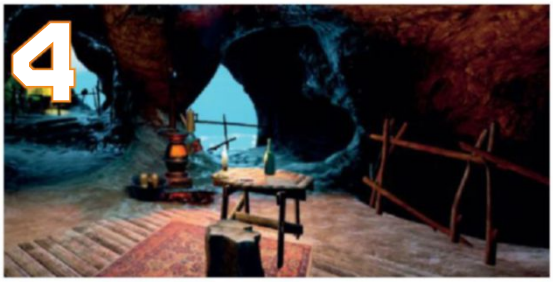
As Microsoft's president and chief legal officer, Brad Smith, said during his keynote, "We do not need our courts to define the laws that govern 21st century technology with laws that come from the era of the adding machine."

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

THE LIST

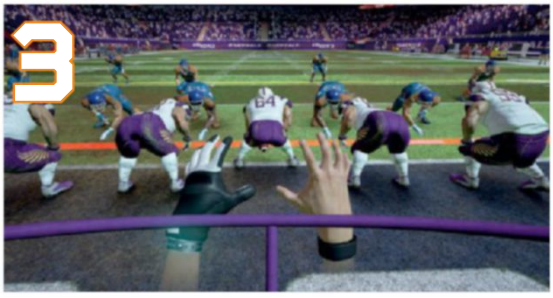
COOLEST VR GAMES AT GDC 2016

8 TRIALS ON TATOOINE Meet Han Solo and R2-D2 on Tatooine and wield a lightsaber against Stormtroopers.



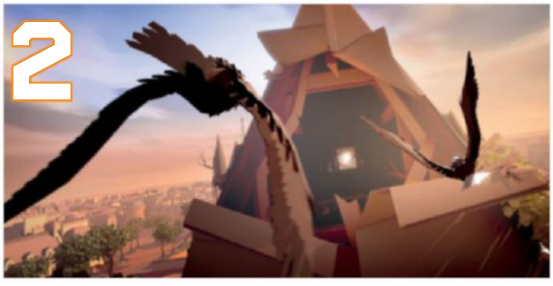
4 THE GALLERY: CALL OF THE STARSEED The narrative VR experience you've been waiting for.

7 RAW DATA Fend off waves of robots with a buddy in co-op using swords, bows, and guns.



3 VR SPORTS CHALLENGE Play football, hockey, basketball, and baseball with Oculus Touch controllers.

6 THE CLIMB Scale virtual mountains in Crytek's breathtaking climbing game.



2 EAGLE FLIGHT A kooky first-person game from Ubisoft, where you control an eagle in abandoned Paris.

5 I EXPECT YOU TO DIE An escape-the-room puzzle VR game that kills you if you fail.

1 THE LAB Valve's *The Lab* is a compilation of fun, polished VR mini games set in the *Portal* universe.

Windows 10

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TALKING

BY ZAK STOREY

Pro Tips From a World-Class Overclocker

Ian "8Pack" Parry from OverclockersUK talks to us about overclocking, water-cooling, and more

There's nothing like building your own perfect system, and at the highest peaks of this passion lie some very select hobbies: extreme overclocking and water-cooling. We spoke to world-renowned overclocker and liquid-cooler Ian Parry about what drove him to start overclocking, and why you should consider moving across to custom water-cooled loops.

Ian "8Pack" Parry—a man who knows his overclocking onions.

Maximum PC: Hello Ian. Can you give us the low-down? What was it that interested you about overclocking?

Ian Parry: I first got into overclocking when I started gaming. I downloaded some benchmarks and ran the test on my rig, then when I compared the results to those that others were achieving with similar systems, I wasn't pleased. I needed to understand why mine weren't as good. I found that the other guys were overclocking, so my competitive nature just made me want to beat their scores. I started looking into tuning my entire system, not just by overclocking but by streamlining the OS etc. for performance.

MPC: What kind of things do you look out for when choosing a processor for your builds and overclock attempts?

IP: What I look for is great overclocking potential of the CPU with its stock cooler and at low volts. I pick a benchmark, usually something multithreaded and quite tough, but fairly short in duration, such as CineBench R15. I make an overclocking profile with low core volts and a high memory OC to ensure a good IMC (integrated memory controller), and grade the CPUs into what speed the processor can pass on R15 with such low voltage. Some will be 4.5, 4.6, 4.7, and so on. The 8Pack CPUs we use in the shop are the top 10 percent of those graded, and they go straight into the 8Pack systems. The best of these I also test on Ln2 to see if they have world record potential.

MPC: Which benchmarks would you recommend, particularly for those people looking to truly test their system's processor?

IP: XTU is recommended by Intel. I suggest you run that in stress test mode, alongside something that will also stress the GPU and hence the PCI X lanes. Unigen's Heaven 4.0 is great for this. This ensures all the controllers on the CPU are maxed-out, and that the CPU will be stable in all applications. Another good test is Real Bench, which again is doing encoding-type work on the processor, whilst doing Open CL work on the GPU. Again, this just stresses all the areas on the CPU. The best stress test for any CPU is the end user just using the PC as they would from day to day. Other stress tests are, of course, just synthetic load simulations. PC Mark 8 is also a pretty good way to fully test a system for all possible uses.

MPC: For those interested in diving into LN2 and extreme overclocking, where would you suggest starting?

IP: You can't dive into LN2 or sub-zero overclocking. It's a

Yep, we're a little jealous of 8Pack's home rig, to put it mildly.

progression from being a very capable ambient overclocker, and something that shouldn't ever be taken lightly. I suggest that aspiring LN2 clockers get a thorough grasp of all aspects of overclocking before using LN2, and then treating the LN2 with the respect it deserves, in terms of both safety and preparing the hardware for sub-zero conditions.

MPC: When Skylake first launched, there was a lot of buzz around a return to the "golden age of overclocking." When do you think that actually was?

IP: In terms of ambient overclocking, the Sandy Bridge architecture was great, and a real leap forward. Many guys could overclock to 5GHz on air-cooling alone. Sadly for XOC (extreme overclocking), these chips had a fairly low cold bug, so a lot of binning on LN2 had to be done to find the best ones. In terms of GPUs, the current Nvidia architecture is a great overclocker. Almost all 980 Tis can reach 1,400MHz-plus on the core, and 1,900MHz on the memory, with little issue. This represents a 35 percent improvement on stock cooler.

MPC: It's hard to argue that liquid-cooling isn't the pinnacle of custom PCs. What's the best part about having a water-cooled system in your opinion?

IP: What I enjoy most is how efficient liquid-cooling is at removing heat. Thus, fans can be run slower, and the overall noise output from a liquid-cooled machine is far lower because of it. At the same time, overclocks are consistently higher on a liquid-cooled system, due to this efficient removal of heat.

MPC: Aesthetics or power? We get asked that a lot at *Maximum PC*. What do you reckon to that age-old argument?

IP: It's about both, with power slightly tipping the balance. There's no point having a great-looking PC if it can't do everything the user wants. When speccing a new PC, I'd first decide on the base spec, then, assuming this is in place, hit all the customizations possible to make a great-looking, custom, individualized system.

MPC: What would you say to those worried about liquid-cooling a PC for the first time?

IP: Liquid-cooling is very safe and easy these days, especially with the amount of guides out there, by both manufacturers and very experienced users. If you're a novice, there are plenty of AIO coolers, offering great performance, low noise, and the user can get used to mounting a water-cooling loop inside their case. EK has made the step from AIO to full custom water-cooling shorter with its Predator range. These are made of custom loop parts, pre-assembled, and ready to go, like an AIO.

Huge data centers, housing massive servers, and networks for things like stock market trading allow water-cooling solutions these days. This tells the story that water-cooling is truly safe when implemented correctly within any PC.

MPC: Where do you stand on soft tubing versus hard?

IP: Both can look great. Several of the Infin8 builds we have at OverclockersUK use soft tubing, and this is not only clean but a different and interesting style of build. It's a great seller, too, and popular with reviewers. My own M-ATX PC at home uses soft tubing. I also think hard tubing, if done well, is great, and all the current 8Pack systems come with it as standard.

MPC: We've started to see separate loops for the CPU and GPU; is there any advantage to this, or is it purely for aesthetics?

IP: There's definitely an advantage to it. The most important one being that the components that are more sensitive to heat, such as the CPU and motherboard, can be placed on a separate cooling loop from the less sensitive components or the GPU, so you can tailor the specific cooling loop exactly to the components.

MPC: What plans do you have? Where will you compete next?

IP: I'm not sure about competing. I have taken a step back from HWBot so I can develop more products. Some I can't discuss because of NDAs with the companies I'm working with, or they're pending release. Maybe next time I compete could be at Computex in Taiwan. It's a competition that myself and my counterpart, Roman "Der8auer" Harthung, who works at Caseking, won last year.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

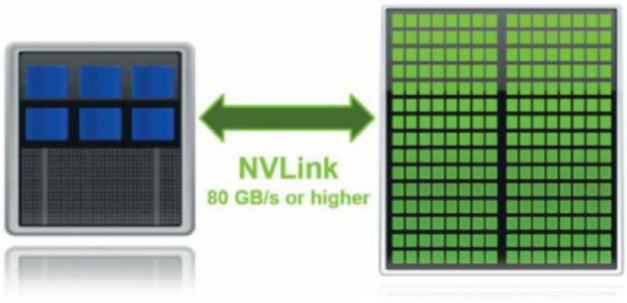
> Picking a GPU
> Preparing for VR
> Fixing a Display

Pick the Right GPU

Hi Doc, I just built a new PC for gaming (I play *Fallout 4, Witcher 3, XCOM 2,* and *Skyrim)* and web browsing (YouTube, Kodi, and so on). It's based on an Asus Sabertooth Z170 Mark 1, Intel's Core i7-6700K at 4GHz, 16GB of Corsair DDR4 memory, a Samsung 850 EVO 500GB boot drive, a Seagate 1TB SSHD for loading games on, and an EVGA SuperNOVA 850 P2 PSU.

The Intel HD Graphics 530 engine in the Core i7 scores 7.1 in the Windows Experience Index, which is 0.4 points higher than the Radeon R9 290 2GB in my A10-based machine, even though it wouldn't run *Fallout 4*. The CPU scores 7.8 and the memory/boot drive both score 7.9. I'd like the video card I buy to get as close to 7.8 as possible.

So, I'm looking for a 4GB card in the $200 to $400 range that can handle my current and future games, including *Hitman, Mass Effect Andromeda, The Elder Scrolls V,* and *Star Citizen*. I'm considering a Radeon R9 390 or a GeForce GTX 970/980. Which would you recommend for my system? **–Jon Poole**



Nvidia's NVLink interface was designed for GPU-based supercomputers, not gaming PCs.

THE DOCTOR RESPONDS: First off, don't worry too much about those WEI scores. Your Radeon R9 290 is hands-down a better piece of graphics hardware than the integrated HD Graphics 530.

The Windows System Assessment Tool runs several DirectX 9 and 10 graphics tests, along with benchmarking Windows Media encode and decode performance. Certain subtests likely favor Intel's hardware, particularly since that powerful AMD Hawaii GPU is almost certainly hamstrung by your A10 APU (regardless of the A10's operating frequency, its performance is more comparable to Intel's Core i3 family).

Before you sink another $200 to $400 on a new graphics card, try that R9 290 in your new build. The Doc is willing to bet it'll feel a lot smoother in a fast Skylake-based machine... right up to 1920x1080. If you plan to game at higher resolutions, then you'll want a 4GB card, at least. A GeForce GTX 980 is out of your price range, and the Radeon R9 390X hits the upper ceiling. A Radeon R9 390 is probably most appropriate if the old 290 doesn't do it for you.

Find My Files

Doc, this may seem like a strange question, but I am trying to download a couple of previous issues and running into a problem. It seems like the download completes without incident. However, I can't find where the file ends up, no matter where I look. Do you have any hints about what's happening? **–Dr. Ron**

THE DOCTOR RESPONDS: Doc, this may seem like a vague answer, but it depends on where your browser is directed to save downloads.

If you're running Firefox, hit Ctrl-J to open the Downloads library. You'll see a chronological list of files; the icon to the right of each opens the containing folder with your download highlighted. The same key combination works in Chrome. With the Downloads tab open, you'll see a link to "Open downloads folder" for easy browsing. Microsoft's Edge responds to Ctrl-J, too. A sidebar opens on the right side of the browser, from which you can "Open folder." Hopefully, between those three browser options, you're able to find your lost copies of the magazine.

Performance Balance

Doctor, I'm planning a lightweight gaming box using an XFX 7950 Double Dissipation Black Edition, and was wondering if an Intel Pentium G3258 Anniversary Edition on a mini-ITX Z97-based motherboard would be a good match. I'm using the processor as a stopgap; I plan to upgrade once my budget isn't so tight. The platform will be connected to a 22-inch LG monitor at 1680x1050. **–Ken Mittelholtz**

THE DOCTOR RESPONDS: The dual-core Pentium is a blast to

↘ submit your questions to: doctor@maximumpc.com

overclock, but it's not the best gaming processor. With that said, a few different factors compel the Doc to make an exception in this case.

First, you plan to replace it once your budget lightens up. Gamers with limited funds are often best off buying low-cost Athlon X4 processors. Unfortunately, AMD's portfolio doesn't give you as much upward mobility, particularly for Socket FM2+. Meanwhile, the Z97 motherboard's LGA 1150 interface will take anything up to a Core i7-4790K down the road.

Second, you're pairing it with a Radeon HD 7950 graphics card. Four years ago, the 7950 was a high-end $450 beast. It's still a competent performer today, landing just under the Radeon R9 280 in most metrics. Intel's Pentium might hold that Tahiti GPU back in certain situations, but the pair isn't completely imbalanced.

Most importantly, you'll be gaming at 1680x1050, where neither the graphics card nor the CPU should be sweating.

Fix a Cracked Display

Hey Doctor, I recently purchased an HP Envy 34 All-in-One. When I got the system set up, I quickly figured out how slow a 5,400rpm hard drive really is. It's been a long time since I purchased a built computer, so I didn't have much choice in components. To make a long story short, replacing that disk necessitates going in through the front of the machine. Swapping drives was easy, but in the process I cracked the screen. I've been "working" with HP for three months now to get it replaced at my cost. They're telling me that it might be doable, though it's basically just a screen replacement.

Do you know of anywhere else I can get this done? Everything I find online is either sales-related or an editorial preview of the system.

–Drew Hudson

THE DOCTOR RESPONDS: There are some services the Doc refuses to pay for, Drew, but replacing a cracked (curved) LCD screen is not one of them.

It appears that the Envy 34 employs a Samsung SVA-based panel (specifically, the LTM340YP01). These are available from a handful of suppliers in Asia. But do you really want to roll the dice on shipping, potential quality issues, or even the do-it-yourself install? See what HP asks for the replacement job, and then decide if the swap using OEM parts is worth it.

Oculus recommends some fancy hardware for the best VR experience. You might want to aim even higher, though.

The Next Ultimate Rig

Hello Doctor, I'm always itching for a reason to upgrade my PC, but I like to wait for major advancements before taking the leap. Currently, I have a six-core Intel processor. When the eight-core models launched last year, I started stockpiling parts for my upcoming build, including an Intel Core i7-5960X CPU, Asus's Rampage V Extreme motherboard, 16GB of Corsair Dominator Platinum DDR4, two 256GB Samsung 840 Pro SSDs, two 1TB 840 EVO SSDs, and a Seasonic Platinum 1,000W PSU.

The final component was an EVGA GeForce GTX Titan X Hydro Copper. But I ended up putting that in my current rig (an Intel Core i7-980X and Asus P6X58D Premium mobo), along with upgrading its system memory to 12GB of Corsair Dominator DDR3. I don't push this system very hard outside of some video transcoding.

That said, I'm eagerly awaiting Nvidia's Pascal-based high-end card for my ultimate rig. I'll use that for 4K gaming and major number-crunching. I plan to keep the current rig for more mundane chores. Which parts should I keep and which should I eBay in preparation for a Pascal-based system using NVLink? **–Chris Comstock**

THE DOCTOR RESPONDS: As of now, there's very little known about the Pascal architecture or how Nvidia plans to implement its NVLink interface. But there's no reason to believe you'll need a connection between two graphics processors capable of 20GB/s. Even the highest-end gaming workstations don't saturate their 16-lane PCIe 3.0 links. Right now, NVLink is intended to improve the performance of GPU-powered supercomputers. So while it's fair to be stoked about Pascal's advancements over Maxwell (3D memory, anyone?), don't sweat NVLink just yet.

If you're giving the Doc carte blanche to pick some killer specs for your next system, hold on to that motherboard, the DDR4 memory, those 1TB SSDs, and the PSU. Consider auctioning off the processor. After all, Intel will likely launch Broadwell-E in the same timeframe as Nvidia's Pascal. Also think about replacing the 840 Pros with a 512GB 950 Pro. The PCIe-based drive will give you sequential reads up to 2.5GB/s over the Asus board's four-lane M.2 slot, minus the risk of a striped array.

Prepare for VR

Doctor, I have subscribed (Zinio) to *Maximum PC* for a number of years and greatly enjoy your magazine, even though I am not into gaming. I am, however, quite interested in VR/AR. This is more from the perspective of immersive travel experiences.

I am ready to buy or build a new PC now, and initially use integrated graphics. Eventually, I'd like to add a discrete GPU, as the strongest performer in AR/VR apps emerges over the next year or two. Today's on-die solutions are quite sufficient for my daily needs (I easily get by now with an old Core 2 Duo E6750/Radeon HD 3650 combination). If it were not for AR/VR, I would most likely be pursuing a more compact PC. Guidance for an office-oriented machine, future-proofed against AR/VR requirements, would be appreciated. **–John Roling**

THE DOCTOR RESPONDS: Enthusiasts are witnessing the dawn of virtual reality, John. The hardware world marches on at its familiarly furious pace, while VR/AR platforms continue to take shape. It's difficult to predict what a future-proofed machine will look like during the tumultuous birth of an industry, aside from "as high-end as possible."

Even though your interest is immersive travel—what many might consider an educational experience—don't expect drastically relaxed hardware requirements. Browsing through the titles showcased on http:\\share.oculus.com, virtual exploration of the Roman Colosseum, GE's Subsea Experience, and up-close encounters with dinosaurs all call for GeForce GTX 780 Ti or higher graphics cards, while more recent additions simply cite Oculus's 2016 recommendations. So, whether you plan to game or not, prepare for the VR experience by buying a system with at least a Core i5-4590, 8GB of RAM, and a GeForce GTX 970 or Radeon R9 290. As for the Doc, he plans to time his next build to include Broadwell-E, a next-gen GPU, plenty of DDR4, and PCIe-based solid-state storage.

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GETTING

TO THE POINT

Ten of the latest gaming mice rounded up and rated

By Ian Evenden

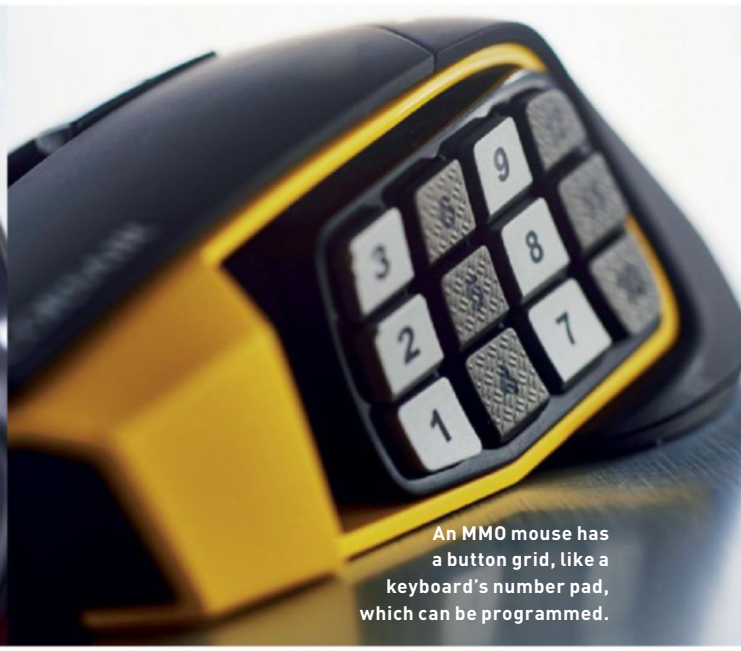
IN THIS FINE COUNTRY of ours, the right to excess is absolute. Sure, you can play games with a lump of plastic that has two buttons and a wheel, plus some sort of movement sensor. Maybe even with a trackpad. Coupled with a keyboard, you can beat anything from an RTS to an FPS to a point-'n'-click adventure. So why do better? Why do you need 12 programmable buttons, a sensor with an ungodly resolution, and a whisk attachment for omelets? It's down to two things: control and options.

The first can be control of movement or control of interaction, and comes down to how fast you need to react. Playing something like *XCOM 2* doesn't require the same sort of reactions as *Homeworld: Deserts of Kharak*, and the dedicated *Kharak* player may well want to send her pointer zooming across the screen at great speed, stopping it with precision on a particular unit. And for that precision you're going to want a high polling rate, which directly affects how often the mouse's position is relayed back to your PC. The higher, the better.

Control of interaction relates to the buttons' programmability. Almost all gaming mice now come with software to control their functions. Being able to map a grenade throw that's just a click of a bumper button on a console controller to an extra button on a mouse can speed up your play and make you more effective in combat. One function that's often fixed is the rocker switch on top of the mouse, which alters the DPI rate on the fly, and the "sniper button," if present, lowers the DPI rate so your aim doesn't wobble when you're trying to draw a bead on an opponent's skull.

These, then, are the latest, and possibly greatest, gaming mice. Enjoy.

This horde of gaming mice contains mostly optical sensors, but laser sensors are also popular.



An MMO mouse has a button grid, like a keyboard's number pad, which can be programmed.

THIS YEAR'S CROP of gaming mice has something in common: useless lighting. It's a customization option that's often mocked in these pages, because it adds nothing to functionality.

The pointlessness of having a mouse that lights up is compounded by the way mice are used—your hand covers them 100 percent of the time they're in use.

Valve showed us, with its hats and other cosmetic items in *Team Fortress 2,* that people were willing to part with cash for upgrades that don't upgrade. Introduced in 2009, there are over 1,200 such "upgrades" for sale on the *TF2* store, although premium account holders can get them as random item drops, too. Sixty-seven percent of *TF2* players own a mask that makes them look like an adorable baby seal, although only seven percent of them equip it. In *League of Legends,* cosmetic upgrades are the only things locked behind a paywall—anything else can be purchased with XP points.

What does this tell us? Well, mainly that people like shiny things. Research from the University of Houston can shine some light on one reason why: it all comes back to water. The attractiveness of a shiny surface is hardwired into us because we once depended on rivers and lakes for water. This manifests itself at an early age—an experiment showed that babies were more likely to put glossy plastic plates in their mouths. From here, as we age, shininess or brightness becomes associated with the fulfillment of needs and living the good life. It's only a short distance from there to making your PC flash bright green.

Buying a mouse with lighting, because you believe it will more strongly fulfill your needs, would be a poor choice, however. That moment when your mom, who hasn't bought a new mouse in 20 years, admires the lighting is a fleeting one. Lighting effects are now so prevalent that they go unremarked by anyone who's flicked through an online store recently.

Basically, lighting up your mouse is BS—something we strive to have a minimum of here. It makes no difference to how the mouse functions, or how it's used.

What's not BS, and can have a real effect on the way your mouse moves and feels, is weighting—something we're seeing less of this year as the focus has altered to pointless cosmetic enhancements.

Adding weight to a mouse adds inertia, the resistance of a physical object to any change in its state of motion. If more force is needed to start your mouse moving, or to make it deviate from its present course, any tiny adjustments, applied without thinking and with little energy behind them, are evened out. Your movements should be smoother and more accurate as a result, perhaps combining with the sniper button for ultimate accuracy.

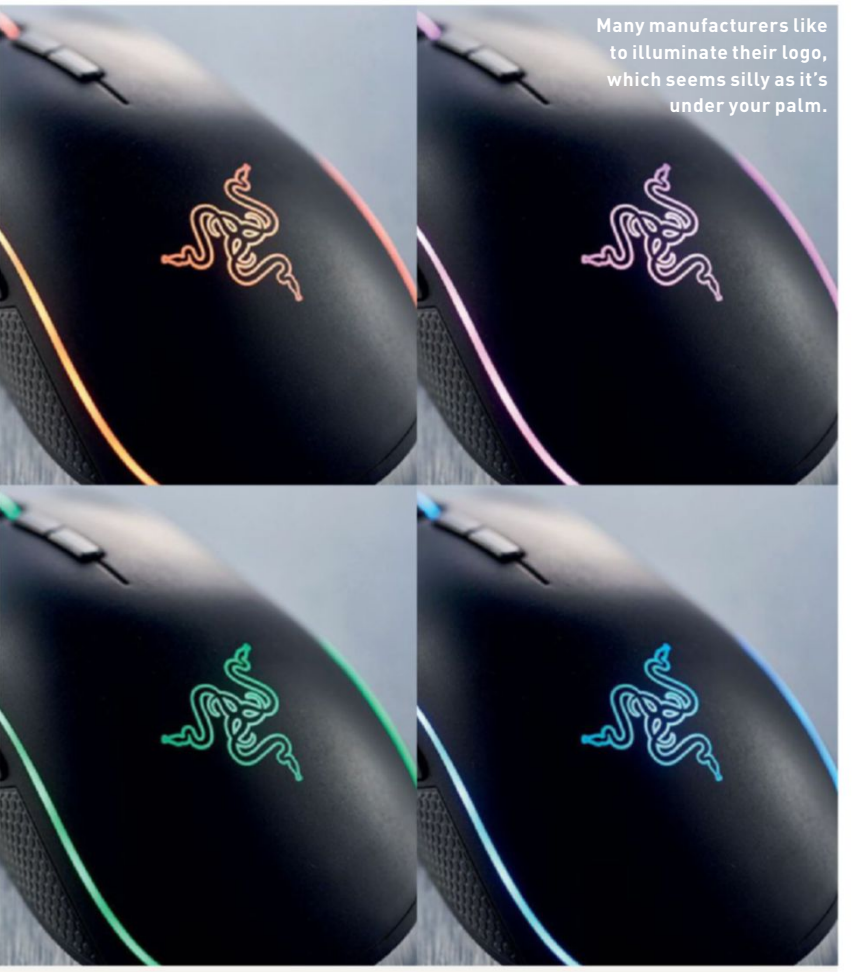
So, if you're playing a game that requires long, smooth, uninterrupted motions, consider adding more weight to your mouse. If it needs lots of small, jerky motions—especially if you need the pointer to stop quickly, as inertia also governs how easy it is to arrest movement—look into making your mouse as light as possible.

In some models, the weights are arranged in such a way as to balance the mouse. A cartridge of individual lumps of metal can be customized to place all the weight on the left side of the mouse, for example, which makes a difference if you lift it off the table often. The natural position of your right thumb (if right-handed) tends to lift the left side of the mouse in this situation, potentially causing it to scrape on the pad or making it harder to replace it flat on the surface immediately. Increasing the weight of this area can help prevent this, leading to a smoother repositioning and a quicker return to the action.

Something else can override all this and make a bigger difference to your success with a particular mouse, however: comfort and familiarity. If the mouse digs into your hand or scrapes your fingers, no amount of weight management is going to turn it into a match-winner. The same goes for your fingers' ability to find buttons without you looking, and without you even consciously thinking. This kind of speed is only achieved with practice, and long familiarity with your mouse. Changing brands or even models could lead to a change in your kill-to-death ratio if you're climbing the leagues of competitive multiplayer, or a lot of frustration if you're trying to get those last stealth achievements in *Hitman.*

Handedness is also an issue. Many left-handers have adapted to using a mouse in their right hand, as devices designed for southpaws are few and far between. Razer sells a left-handed version of its popular DeathAdder gaming mouse, but any lefties liking the look of Logitech's loveliness will be left in low spirits. The same goes for the strange MMO mice, with a whole numeric keypad bulging from their side as if they've received a large dose of radiation. They're built around the thumb of the right hand, making their use by a leftie at first seem

Logitech's weight system enables you to change the balance of the mouse, and how much resistance it puts up.



Many manufacturers like to illuminate their logo, which seems silly as it's under your palm.

hopeful—as the buttons fall under your more dextrous fingers—then hopeless as the shape of the mouse body makes it an uncomfortable endeavor. Perhaps the best option is to go for an ambidextrous model, of which we have a couple on test here.

Programmability of buttons can be of some help if you're struggling with your mouse, but it's never going to flip a right-handed mouse into a left-handed model. The most common mouse interactions outside of gaming are clicking a window's close button and hitting the back button in a browser. Being able to program additional buttons to carry out these tasks can speed up your interactions with your PC, and a particular favorite of ours is being able to program the wheel, in models where it clicks left and right, as well as down, to scroll left and right, complementing the vertical scroll of the rolling wheel. This tames large documents, especially in photo-editing or publishing applications, and helps out with those annoying web pages that don't perfectly resize to a snapped browser window.

While there's more to a gaming mouse than just gaming, the majority of these models are going to appeal to those who like to shoot, fly, or micromanage. Despite what controller manufacturers would like you to think, the mouse and keyboard combo has yet to be beaten as a PC game control scheme, and absolutely any of those scattered over the following pages would make a fine upgrade from the two-button-and-a-wheel device that sits by so many PCs. Whatever you want from a mouse, there's bound to be something out there that appeals.

Lightness of being

The United States' rising obesity rate has been attributed to everything from high-calorie diets to sedentary lifestyles, but we would like to propose another possible cause: mouse lighting systems.

A huge 68.8 percent of US adults are considered to be overweight by the National Institute of Health, which rises to 74 percent among young men. No state has less than 20 percent of its population above the level at which they are considered obese.

Alarmed at this, we put down our buckets of fried chicken and turned our keen scientific minds to the 2010 publication of a paper from Ohio State University, in *Proceedings of the National Academy of Sciences*, which examined how night-time light can affect weight, body fat, and glucose intolerance in male mice. The study discovered that persistent exposure to even a little light, when it should be dark, leads to increases in all three.

Light's role as a regulator of the body clock is already well understood, and a genetic cause for obesity has been identified—again—in mice. Ohio State wanted to test the effect, if any, of ambient lighting on waistlines. The mice were split into three groups. One group was kept in natural lighting conditions, one was exposed to 24-hour daylight, and the last group was kept in a natural cycle but with a dim glow instead of true darkness at night. Each group was fed comparable amounts and was not stopped from moving around.

After eight weeks, the mice who'd had more light at night had put on 50 percent more weight than those kept in a natural day/night cycle. They also put on more fat, rather than increased muscle, and showed a decreased tolerance to glucose in their bloodstream, a symptom often associated with diabetes later in life.

Now, if dim lighting can make a mouse fatter, imagine what dim lighting from a mouse does to you! *(You're fired—Ed.)*

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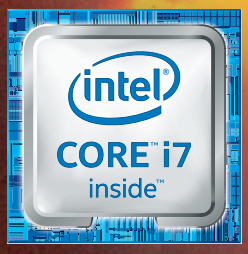

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- Full sized Keyboard with white-LED backlight
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COOLER MASTER XORNET II

Redesigned but still a little weird

A SPECIALIZED MOUSE for the claw gripper, the Xornet II may feel a little unusual to someone who's not prepared to extend their fingers in just the right way. It's been redesigned from its previous incarnation, and now sports a new sensor, altered button shapes, a light-up scroll wheel, and a more firmly attached cable.

Unfortunately, if you're not fond of the claw, this might not be the mouse for you. A ledge on the right is easy to mistake for the right button, and it's simply uncomfortable if you try to palm it, seeming to twist off to the left under your hand. At 0.3 lb, it's relatively light, and there is no way to alter that weight.

The matte black finish is classy, with the kind of microtextured grippy side panels that will endear it further to its target audience. The onboard switches are Omrons, but the mouse suffers in terms of features beyond that. There are only two extra buttons, to make a total of seven, including DPI changers and wheel, and the optical sensor's maximum sensitivity is 3500 dpi—although that's an improvement of 1,500 dpi over the previous version.

This lack of headline features is a shame, but contributes to keeping the price down. There's a limited audience out there for a mouse like this, and studding it with the kind of extras that would push up its cost would limit it even more.

The grip is what will draw people to this mouse, and probably what will make them stay. The fact that it's very reasonably priced helps, but some will pick this over devices that offer greater resolution, more buttons, or grippier finishes, just because it works for them. If you like to feel full contact between your palm and the back of the mouse, walk on by, but for anyone who likes to keep their fingers stiff while gaming, this is well worth a try.

SPECIFICATIONS

Sensor	Optical
Polling Rate	1,000Hz
Max Sensitivity	3,500 dpi
Programmable Buttons	7
Weight	0.3 lb

VERDICT 6

Cooler Master Xornet II

XAVIER Nicely updated claw-grip mouse; light and cheap.

HORNETS Limited appeal; relatively low resolution.

$35, http://gaming.coolermaster.com

CORSAIR SABRE OPTICAL RGB

A solid performer at a reasonable price

THE FIRST CORSAIR model in this test is a stripped-back, basic model that retails for a reasonable price. Corsair is known for color schemes that mix jet-black plastic with a garish highlight color, and the Sabre is no exception. You can, of course, change this highlight color, as it's supplied by LEDs.

The Sabre is very lightweight, moving easily across any surface, and changing direction with minimum effort. It's fairly low and wide, designed for claw grippers, but is more forgiving to the palmer than the Xornet II. There are eight programmable buttons, including the wheel, with Omron switches rated for 20 million clicks, and a very nicely braided cable that stretches 5.9 feet toward your USB port of choice.

The optical sensor resolution tops out at 6,400 dpi, and there are no weights to increase the heft. The smooth top surface makes moving between the narrow main buttons and the wheel simple—there's no doubt where one ends and the other begins when all you've got to go on is the feedback of your fingertips. Below the side buttons sits a recessed groove for your thumb, but these buttons aren't of the angled type, which can be pressed by rolling your thumb up—you have to move it to push them. A shame, as the presence of the groove is crying out for such a movement-saving design.

Lighting is configurable across four zones, which can display the same or different solid colors, as well as changing patterns. As usual, it's all programmed with the PC software package, and the mouse contains a small amount of storage to save profiles to, if you're not using your usual PC.

Such a basic model thankfully sells for a reasonable price. The Sabre is a solid, if unremarkable, performer at one of the most contested price points—its selling point is probably its light weight, and we're not sure that's enough to make it stand out.

SPECIFICATIONS

Sensor	Optical
Polling Rate	1,000Hz
Max Sensitivity	6,400 dpi
Programmable Buttons	8
Weight	0.2 lb

VERDICT 7

Corsair Sabre Optical RGB

SUPER SABRE Reasonably priced mouse; lightweight.

MIG-19 Basic; unremarkable.

$50, www.corsair.com

CORSAIR SCIMITAR RGB

Just how many buttons do you need?

A LARGE MOUSE with a calculator strapped to its side, Corsair's Scimitar is a member of that strangest of tribes—the MMO mouse.

It's easy to see where the design came from—the demands of MMO games that spells and attacks be assigned to numerical keys for easy access—but the Scimitar suffers from the same problem we have with all MMO mice: using the damned thing.

The buttons come in alternating lines of rough and smooth textures, but it's not enough—we found it hard to tell where our thumb was on the array without looking, and reaching all the way back to 10, 11, and 12 meant a complete repositioning of the hand on the mouse body. You can still click the primary buttons with your finger about halfway down them, but go any further toward the rear, and they are unpressable.

The wheel is a little loose, but turns with a positive notchiness, and the body of the mouse is very big. This could be seen as an advantage—the right thumb is freed of any support duties and left to dangle over the button array, doing a one-legged jig across the world's most complex game of *Dance Dance Revolution*, and probably comes down to the challenge of fitting 12 buttons, with their switches and support frame, vertically on the side of a mouse. Those of a small-handed disposition may find it a bit of a stretch. An included tool engages with a hex nut on the base to shift the keys around a bit, so you can get them just right.

The sensor is a reasonably impressive 12,000 dpi optical model, and the software that comes with the Scimitar enables not only the programming of the buttons for single keystrokes, but for macros made up of multiple presses, too—and, yes, you can mess with the lighting if you like. This is another specialized mouse, with a particular audience in mind. We just hope that audience has big hands.

SPECIFICATIONS

Sensor	Optical
Polling Rate	1,000Hz
Max Sensitivity	12,000 dpi
Programmable Buttons	8
Weight	0.3 lb

VERDICT **7**

Corsair Scimitar RGB

OTTOMAN Many, many buttons; large and solid.

MORMAN Limited appeal; button identification tricky.

$80, www.corsair.com

LOGITECH PROTEUS SPECTRUM G502

The best mouse of 2015 gets a colorful update

PARDON US FOR BEING subjective, but this could be the best mouse we've ever used. And we've used a few, from $5 barely functional lumps of plastic to Apple's appalling G3 hockey puck to the RAT. This model replaces the Proteus Core, which we liked a lot the last time we looked at mice.

The new G502 is tall and solid, making its presence known in your palm, yet still being light enough to push around easily. Should it be too light, there are five 0.13 oz weights, shaped like some sort of horrible futuristic boomerang bullets, that fit in the base, enabling you to move the center of mass.

With a body that looks like something Adam Jensen would use, even down to the triangular motif etched into the rubber side pads, it's certainly a futuristic design that stands out from the rest of the units in this test. Only the RAT series from Mad Catz looks more aggressively styled. The upshot of this is that the Logitech feels slightly different to use from other mice, but the body is so comfortable, you'll become familiar with it quickly.

Apart from the ability to display 16.8 million colors, this new model is identical to the Proteus Core, with a 12,000 dpi optical sensor, 11 programmable buttons, and the ability to save profiles to the mouse, rather than relying on the PC software.

One of our favorite features is the clutch button that disengages the wheel's notches, allowing it to spin freely—and it goes on spinning for some time after you remove your finger, a benefit of the metal rim. If there's a downside, it's that the lighting doesn't really feel like much of an upgrade—we'd have liked to see a newer sensor module or some refinement of the switches under the buttons. But when your product is this good, we understand Logitech's desire to stick with a proven formula.

SPECIFICATIONS

Sensor	Optical
Polling Rate	1,000Hz
Max Sensitivity	6,400 dpi
Programmable Buttons	8
Weight	0.2 lb

VERDICT **9** KICK ASS!

Logitech Proteus Spectrum G502

SPECTRUM Solid build and performance; highly customizable.

C64 No massive refinement.

$80, www.gaming.logitech.com

MIONIX CASTOR

A black mouse that's classy and understated

WHAT AT FIRST LOOKS LIKE it's going to be an ambidextrous mouse turns out to be nothing of the sort. This is a right-handed-only zone, with its ergonomics subtly tuned to support only the ruling class in our unequal society.

The Castor wants to position itself as a premium product, and almost manages it. The sensor is a 10,000 dpi PMW-3310 optical unit that boasts a complete lack of hardware acceleration. There are six fully programmable buttons, the shape supports all types of grips—although is better taken fully in the palm—and gamers baffled by the current trend toward bigger and bigger mice will be pleased to see that it's one of the smaller models we've tested.

Matte black mice always look good, and the Castor is no exception. Its four-layer rubber coating means it's not going to easily slip out of your hand, and the lighting effects have the standard range of solid, blinking, breathing, and pulsating settings. There are no additional weights to change the mass of the mouse, which is nicely balanced and not over-heavy straight out of the box.

The result of all this is that the Castor has become a bit forgettable. The build quality is excellent, the sensor unimpeachable, the software comprehensive, and the ergonomics extremely comfortable, as long as you're right-handed, but very little about the Castor sticks in the mind.

It would be wrong to call such a mouse boring, because so much of the fluff manufacturers add to their latest models in order to make them stand out from the pack ends up looking ridiculous. Perhaps we're just not used to this level of quality from something not festooned with flashing lights and strangely angled surfaces. Perhaps—just perhaps—the addition of purely cosmetic flourishes to a product has become linked in our minds with the fulfillment of our needs after all.

SPECIFICATIONS

Sensor	Optical
Polling Rate	1,000Hz
Max Sensitivity	10,000 dpi
Programmable Buttons	6
Weight	0.3 lb

VERDICT **7**

Mionix Castor

✚ **CASTOR** No hardware acceleration; excellent build quality.

➖ **POLLUX** Little bit forgettable.

$70, http://mionix.net

RAZER DIAMONDBACK CHROMA

The thin-bodied mouse returns to rattle us

ONE OF THE FORGOTTEN KINGS of the gaming mouse world, the Diamondback has won an armful of awards, and claims to have had the first "optical gaming sensor"—although what marks out a sensor as being for gaming we're not sure. It's also always lit up, so perhaps it's to blame for the rash of LEDs. The Diamondback brand dropped off the radar in 2007, eclipsed by larger, more modern designs, but has now returned.

The slim, tapering shape is unusual; your right thumb tucks right into the side but your fingers are left without enough to get a proper hold. It can sit forward in your grip, teased in your fingertips as if you're making delicate adjustments to a dial or a lover. It's not uncomfortable, even if it's a bit low for our tastes, but after years of increasing girth, it takes a little getting used to. The 2016 Diamondback feels less flat than the original, and this improves the comfort.

The lighting, which occupies a continuous thin strip around the body of the mouse and the wheel, isn't too horrifying, even though it's set by default to coruscate through its entire spectrum in a way that'll at first fascinate you before boring you to death. It would be even nicer without the ridiculous three-headed logo that also flashes, but at least that's covered by your hand. It's also available as a truly ridiculous Collector's Edition. Does anyone collect mice? Maybe keep them in a glass case and show them proudly to visitors? If you do, write in.

The original Diamondback was released in 2004, a more civilized time, before colored lights were common and marketing philistines crammed our nimble pointing devices full of unnecessary gubbins. This new model has thoughtfully updated the original, with a 16,000 dpi sensor and access to Razer's latest software. It's not a mouse everyone will be comfortable using, though—the epitome of "try before you buy"—and it feels a little basic for the price.

SPECIFICATIONS

Sensor	Laser
Polling Rate	1,000Hz
Max Sensitivity	16,000 dpi
Programmable Buttons	7
Weight	0.2 lb

VERDICT **7**

Razer Diamondback Chroma

✚ **DIAMOND** Updated classic; high-resolution sensor.

➖ **CARBON** Thinner than most mice; bit expensive for what you get.

$90, www.razerzone.com

RAZER MAMBA TE CHROMA

A comfy device, with lots to recommend it

THERE ARE TWO VERSIONS of this mouse. The Luxury Edition doubles the price and adds optional wirelessness, customizable click force through a couple of hex nuts on its base, and comes with a recharging stand that lights up. Nnnnngh. There's not a lot else about it that deserves the "Luxury" label, however.

The Tournament Edition is the basic model, and probably the more successful of the two. It's a large mouse that fits well in the hand, with a humped back to increase comfort. Like every other mouse in this test, it's permanently wired to your PC. As with its stablemate, the Diamondback, there's a lighting strip that, by default, slowly cycles through its colors. It doesn't run all the way around the body, as it does on its smaller cousin, sensibly breaking under the wrist. The large Razer logo also lights up—a feature the Luxury Edition lacks—and if you've got a full house of Razer products on your desk, you can synchronize the lighting across headset, keyboard, and mouse using the Razer software.

And the Mamba is lovely, a really nice mouse to use all day. So nice that we'd call the Luxury Edition unnecessary. It's not overburdened with switches, with only two extra buttons either side, and no way of making it ambidextrous, but the wheel clicks left and right, and rolls satisfyingly under the middle finger, with big notches so you know when it's clicked into place.

It's fairly heavy, and a bit back-heavy, but the rubberized area below the side buttons is a good thumb rest, allowing a decent grip, no matter what hand position you prefer.

The sensor is a 16,000 dpi laser unit, all nine buttons can be reconfigured, and the seven-foot cable feels generous. The Mamba is a great all-round package that does everything it sets out to do.

SPECIFICATIONS

Sensor	Laser
Polling Rate	1,000Hz
Max Sensitivity	16,000 dpi
Programmable Buttons	9
Weight	0.3 lb

VERDICT 8

Razer Mamba TE Chroma

BLACK MAMBA Comfortable; grippy; precise.

MAMBO NUMBER FIVE Could do with a few more buttons.

$90, www.razerzone.com

RAZER NAGA MMO

Razer peppers the MMO mouse with buttons

WITH A LASER SENSOR and 19 programmable buttons, the Naga Chroma is trying very hard to get some attention, and it will probably succeed at this task by dint of big numbers alone.

As an MMO mouse, the Naga falls into the same traps as the Corsair Scimitar, although it makes its buttons easier to locate by providing them with a concave top surface, so there's less chance of pressing two at once. If you have to look at it, Razer has chosen to rotate the numbers printed on the array through 90 degrees, presumably to make them easier to read, although we're not sure about that, having tried it. The wheel is a tilting model that moves very positively, its rubber tire nicely studded with a pattern of dots to prevent slippage.

The ergonomic design makes it feel a little smaller than the Scimitar, although it still has to integrate the button array into its structure, so any space savings Razer has achieved are going to be minimal. The black plastic shell looks like quite a shiny one, but in the hand, the Naga proves to be grippy and ever-so-slightly textured all over. A finger rest on the right-hand side is a thoughtful touch, giving those underused digits somewhere to hang out while the thumb does all the work.

This version of the Naga is the wired Chroma, which ups the colors it's capable of displaying to the expected 16.8 million (up from one—green—on the previous iteration), and also comes in a left-handed version. A wireless edition, the Epic Naga, is also available, and comes with a magnetic charging stand.

You have to love MMOs (or possibly accounting) to buy a mouse like this, and the Synapse software makes configuring its button array very straightforward. Its appeal may not be broad, but if you have a need for all those buttons, you won't be disappointed in the Naga.

SPECIFICATIONS

Sensor	Optical
Polling Rate	1,000Hz
Max Sensitivity	8,200 dpi
Programmable Buttons	19
Weight	0.3 lb

VERDICT 7

Razer Naga MMO

SCOVILLE Good sensor; lots of buttons; nice wheel.

SMALLVILLE Niche audience; no really; can be tricky to use.

$80, www.razerzone.com

ROCCAT KIRO

Perfect for lefties on a budget

THE KIRO IS A MOUSE you can use with either hand. We already have a perfectly good word for such a thing, but Roccat has decided to invent its own: "superdextrous." Super, of course, comes from the Latin word "supra," meaning "above" or "beyond"—so we quite expect to be able to operate this mouse with our feet.

We can't, of course—the webbing between our toes gets in the way—but the Kiro is cleverly designed to be reconfigured for right- and left-handers. You get four "sides" in the box, two with buttons and two without, enabling you to place additional switches (all Omrons) where you need them the most. They're attached by magnets, and snap into place. Claw grippers will be able to use all four extra buttons, while palmists will probably prefer to have one set, easily reachable with the thumb or by curling back a finger, if you're into hand yoga.

The body is heavy, with no way of removing any weight, and features a soft-touch coating. The lighting is again subtle, being limited to the logo on the back, and is controllable from the setup app. The sensor is a 2,000 dpi optical model, which can be doubled in software. The results aren't great, however, and we don't recommend doing that unless you absolutely have to.

This is another budget mouse, and wins over the Rival, below, in terms of its "superdextrous" customizability. Left-handers will certainly appreciate this, and the additional weight of the Kiro will raise it up in the opinion of others. The weight is positioned toward the back of the mouse, throwing off its balance somewhat.

The buttons are responsive, and custom assignment through the Swarm software is simple. A good choice for anyone looking to spend less than $50, offering additional features at the cost of some clunky design.

SPECIFICATIONS

Sensor	Optical
Polling Rate	1,000Hz
Max Sensitivity	2,000 dpi
Programmable Buttons	7
Weight	0.2 lb

VERDICT **7**

Roccat Kiro

✚ **SABERTOOTH** Ambidextrous; reasonable price; replaceable magnetic sides.

➖ **CATFISH** Low maximum resolution; back-heavy.

$40, www.roccat.org

STEELSERIES RIVAL 100

Not a broad mouse, but it has broad appeal

SOMETIMES THE SIMPLE THINGS in life are among the best. This is a good basic mouse, with only two additional buttons, and a sensitivity switch on top. With a smooth matte plain black finish, the Rival 100 fits well in our palm—although claw grippers will get on well with it too—and the programmable lighting is kept to just the wheel and the logo on the rear.

There's a lot to like about this budget offering—remember, it's only $40—but it doesn't feel like it's built to a budget. There's a good rubbery grip at the side, bobbled for extra pleasure, and it's light, too, although there's no option to increase the weight. The shape is ambidextrous, but there are only buttons on the left-hand side, catering to the right-handed population. The buttons have new switches, and are lighter and easier to press than the original Rival.

The wheel rotates much as you'd expect, with nothing fancy such as clicking left and right. It feels a little less solid than on pricier models, but still works perfectly in general use. There's a hint of the Microsoft mouse—a classic design that's still used today—about the body, and it's likely to appeal to a broad range of users.

Underneath, SteelSeries has splashed out on a home-grown optical sensor, rather than an off-the-shelf part, and it performs well. The maximum resolution is 2,000 dpi, but this can be boosted in software to 4,000 dpi, as with the Kiro above. Just like using the digital zoom on your cellphone camera, though, noise creeps in and the quality is degraded, so we still don't recommend doing this.

Overall, this is a great budget offering. It may not have the extras that other devices in this test have, but it also doesn't suffer from their price tags. It's hard to go wrong with something this well made for this kind of price.

SPECIFICATIONS

Sensor	Optical
Polling Rate	1,000Hz
Max Sensitivity	4,000 dpi
Programmable Buttons	6
Weight	0.3 lb

VERDICT **8**

SteelSeries Rival 100

✚ **RIVAL** Great budget mouse; no hardware acceleration; broad appeal.

➖ **ENEMY** Slightly flimsy wheel; only two extra buttons; low max resolution.

$40, https://steelseries.com

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AND THE WINNER IS...

LOGITECH PROTEUS SPECTRUM G502

THIS YEAR'S GENERATION of gaming mice is extremely similar to the previous one. Apart from a few cosmetic changes here and there, there's no great technological breakthrough that makes any of them a must-buy. Some of them are even identical to their previous iterations.

Far be it from us to advise not spending your money (that's not why you buy this magazine, after all) but if you've purchased a new mouse in the last year or so, the best advice is probably to hold off shelling out for another one.

If you are in the market for a new rodent, however, the smart money would go on one from Logitech, Razer, or SteelSeries. Those looking to splash out on something a little more luxurious will find the Proteus Spectrum a satisfying device to use—it's large and quite heavy; a mouse you know you're using, rather than one that fades into the mat.

OF MICE AND MEN

Razer's Mamba is another great design, a mouse you can use for anything and not feel like it's digging into your hand or punishing your wrist. Finally, for the budget-conscious, SteelSeries' Rival 100 can be picked up for less than $40, and is a lovely thing you'll enjoy using, perhaps even more for the knowledge of how little you spent on it. Honorable mention in this category must also go to the Corsair Sabre, which beats the Rival in almost every way on paper—more buttons, more sensitive, lighter—yet fails to be as comfortable to use once hand meets plastic.

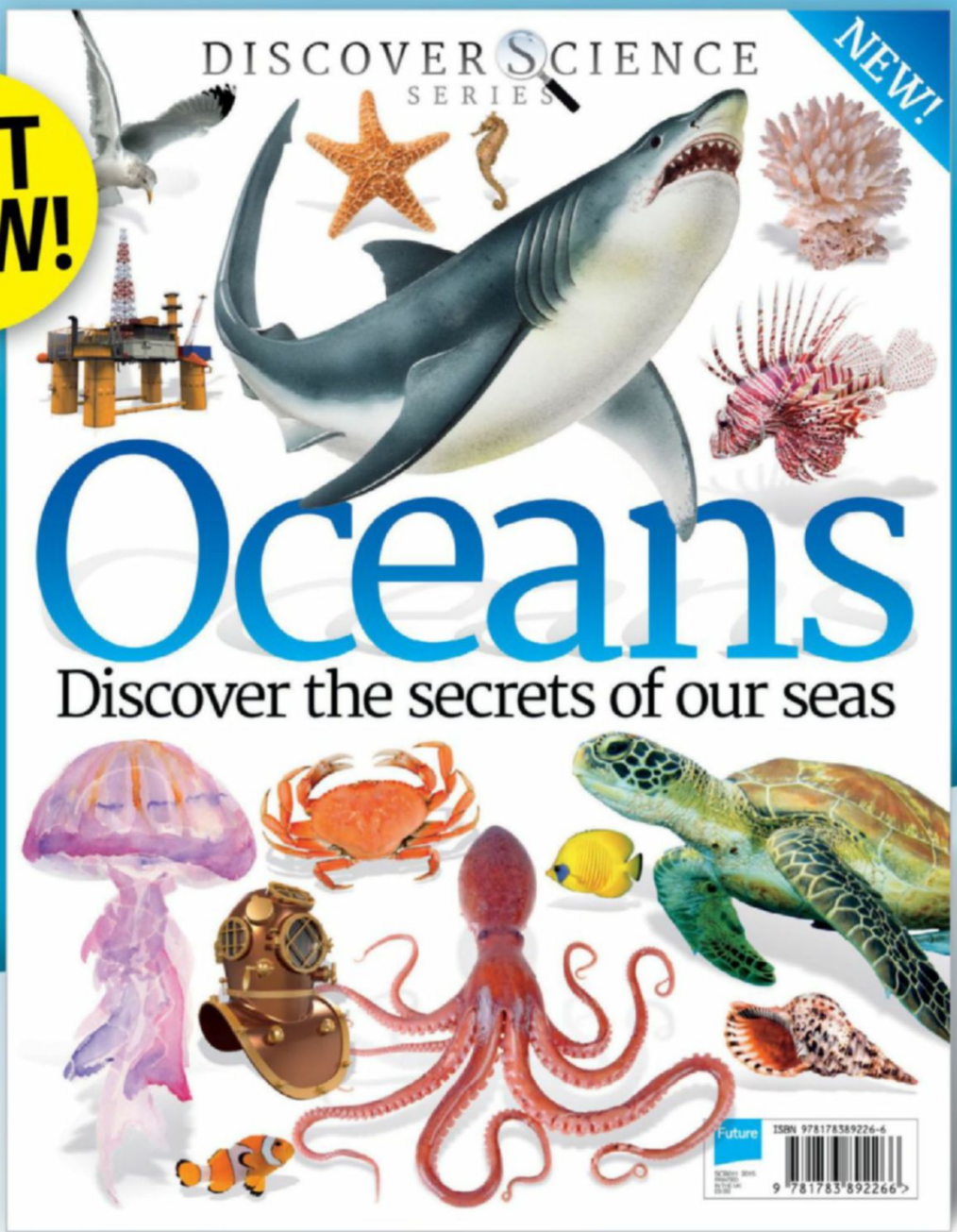
The Mamba's stablemate, the Diamondback, is a strange creature that would be easy to recommend as long as you can try it out first. Its thin, tapering shape can work extremely well, but it's different from almost everything else on the market, and some people are just going to hate it from the moment they touch it. Buy it from a physical shop if you can, and open the box if the shopkeeper will let you.

The budget mouse sector is particularly vibrant, as despite the lack of new headline features on the flagship mice, models such as the Rival 100 and Sabre are the equal of almost anything produced in the last 10 years. There's no creaky plastic, wobbly buttons, or loose wheels to be seen in this selection, as parts and build quality trickle down from the more expensive units. SteelSeries has also given us a glimpse of the next great mouse innovation, with its not-yet-available Rival 700—a customizable OLED display, which can display team logos or useful information, such as cooldown timers, right down by your thumb where you can't see it. We look forward to getting our hands on that one, and seeing how other manufacturers run with the idea.

For now, and despite the high quality of the cheaper mice, it's a flagship that triumphs in our tests. The Proteus is the undeniable winner, just as it was the last time we looked at gaming mice. Logitech has been doing this a long time; it made its name making mice, and its engineers know how to build a product that feels premium. The price is premium, too—twice as much as the Rival, and one of the most expensive units on test here. As you progress up the price ladder, the law of diminishing returns takes full effect—a Mamba will set you back $10-$20 less than a Proteus, and is fully capable of fulfilling your needs. The number of people who will take full advantage of the Proteus's configurable weights, for example, will be limited.

> “Logitech made its name making mice, and its engineers know how to build a premium product.

DELVE DEEPER INTO NATURE



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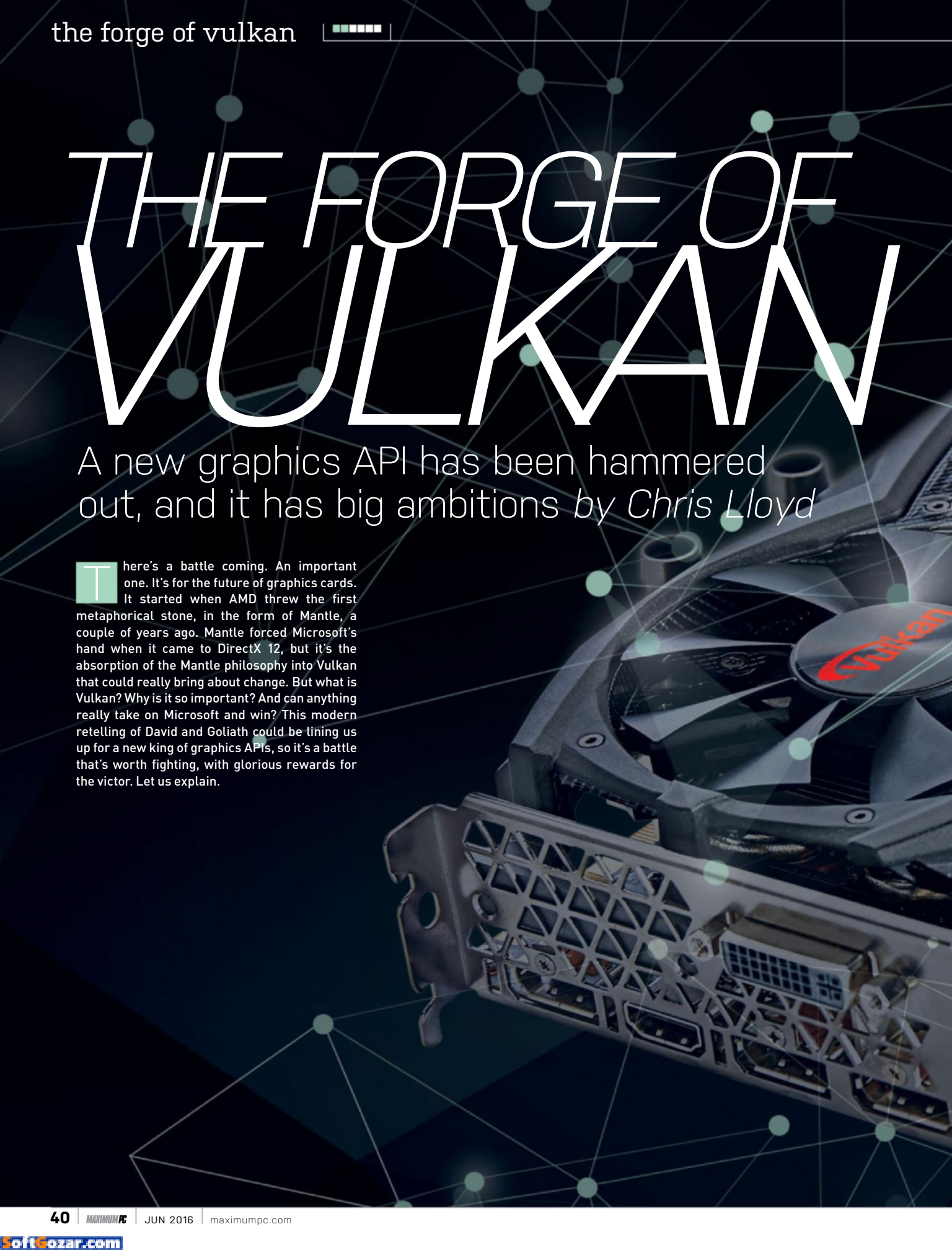
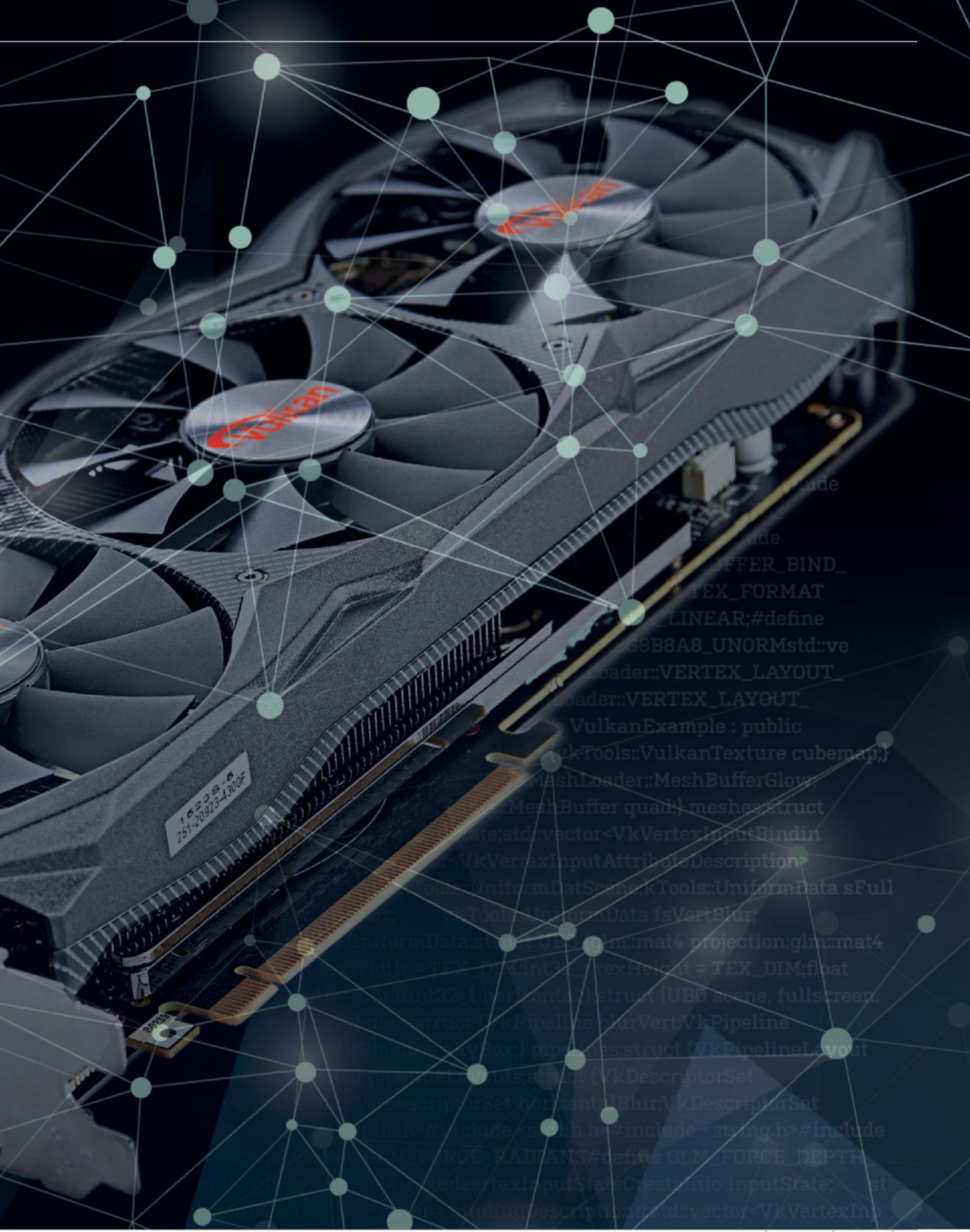
THE FORGE OF VULKAN

A new graphics API has been hammered out, and it has big ambitions *by Chris Lloyd*

There's a battle coming. An important one. It's for the future of graphics cards. It started when AMD threw the first metaphorical stone, in the form of Mantle, a couple of years ago. Mantle forced Microsoft's hand when it came to DirectX 12, but it's the absorption of the Mantle philosophy into Vulkan that could really bring about change. But what is Vulkan? Why is it so important? And can anything really take on Microsoft and win? This modern retelling of David and Goliath could be lining us up for a new king of graphics APIs, so it's a battle that's worth fighting, with glorious rewards for the victor. Let us explain.





Graphics are changing. We're not talking about new GPUs, better CPU graphics, or anything like that—we're talking about a fundamental shift in how we access polygon-pushing hardware. AMD tried it with Mantle, and Microsoft added components of it into DirectX 12. The goal is much, much faster 3D. And when it's done right, it works. What's new is the emergence of a major new player, with some serious backing and development behind it. It plans to create a completely new, ground-up design of low-level, cross-platform graphics API: Vulkan.

Vulkan promises to have a huge reach—previous low-level APIs have been tied to operating systems or specific hardware. Vulkan will run on Windows 7 through 10, Linux, and Android. Hardware support aims to run across all the major GPUs, from those in mobiles through to consoles and desktops. "The endless war between performance and portability is over," claims one developer. It promises to be open, layered, scalable, and fast. So far, so good.

The high-level problem

The traditional high-level API has been with us for years. It sits between your application and the driver, directing and interpreting data traffic. It sends application calls to the right bit of hardware, and routes data calls from the CPU to the GPU. API features have mushroomed over time, as the complexity of 3D function libraries and graphics card hardware developed. The API has put on a lot of weight, becoming complex and requiring a similarly challenged driver.

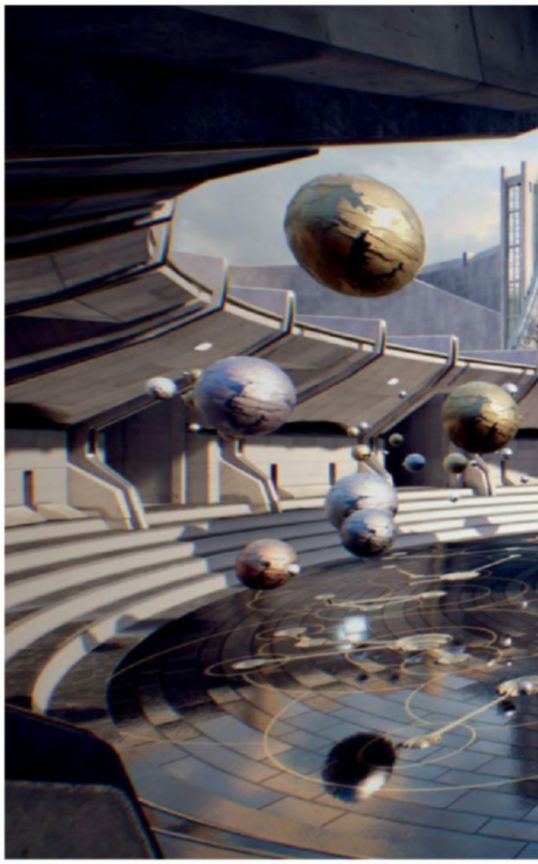
Meanwhile, processors and GPUs have become multi-core. The high-level API was designed in a single-core world, sending data in a serial fashion between two devices now capable of parallel operation. Every time you want an object in a 3D scene, the game's 3D engine requests data from the CPU; every frame can make tens of thousands of these calls. The API was running these on a single core, one at a time. Graphics performance was hitting a bottleneck, the inefficient API incapable of fully utilizing the new hardware, and a high driver overhead. Simply using faster hardware didn't get the results it deserved.

The low-level solution

This bottleneck troubled AMD. It had favored multi-core designs for CPUs, at a time when Intel had concentrated on getting faster cores. This put AMD at a disadvantage with 3D graphics. The Radeon GPU is good at asynchronous compute, processing 3D geometry in parallel, exactly what a high-level API was bad at delivering.

The solution was a low-level driver, called Mantle, launched in 2013. This had new low-level code, which worked much closer to the hardware. Data calls were managed in parallel, using all the cores to pass data across to the GPU in batches for parallel processing. There were other improvements and optimizations, but this main trick was the key. The bottleneck was relieved and the effects were impressive: frame rates jumped dramatically, doubling or more in the right circumstances.

Mantle showed the way, but it never achieved widespread support, and was really aimed at AMD's hardware. It was only ever supported with ATI Catalyst driver, despite promises of more widespread support; there were only about 10 games that could put Mantle to proper use. After



a couple of years, AMD dropped it, before it had made a full public release of the SDK. A promising start but AMD had bitten off more than it could chew. It gave Microsoft pause for thought, though, as it highlighted the drag and bloat of the main players.

DirectX 12 was launched with Windows

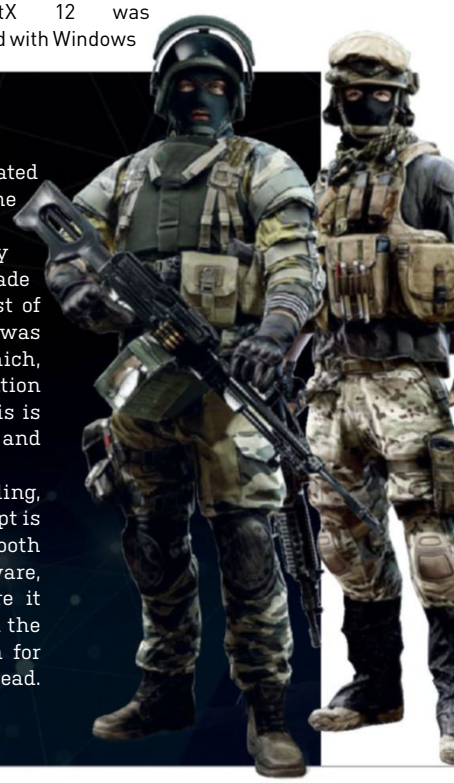
A very short history of the graphics API

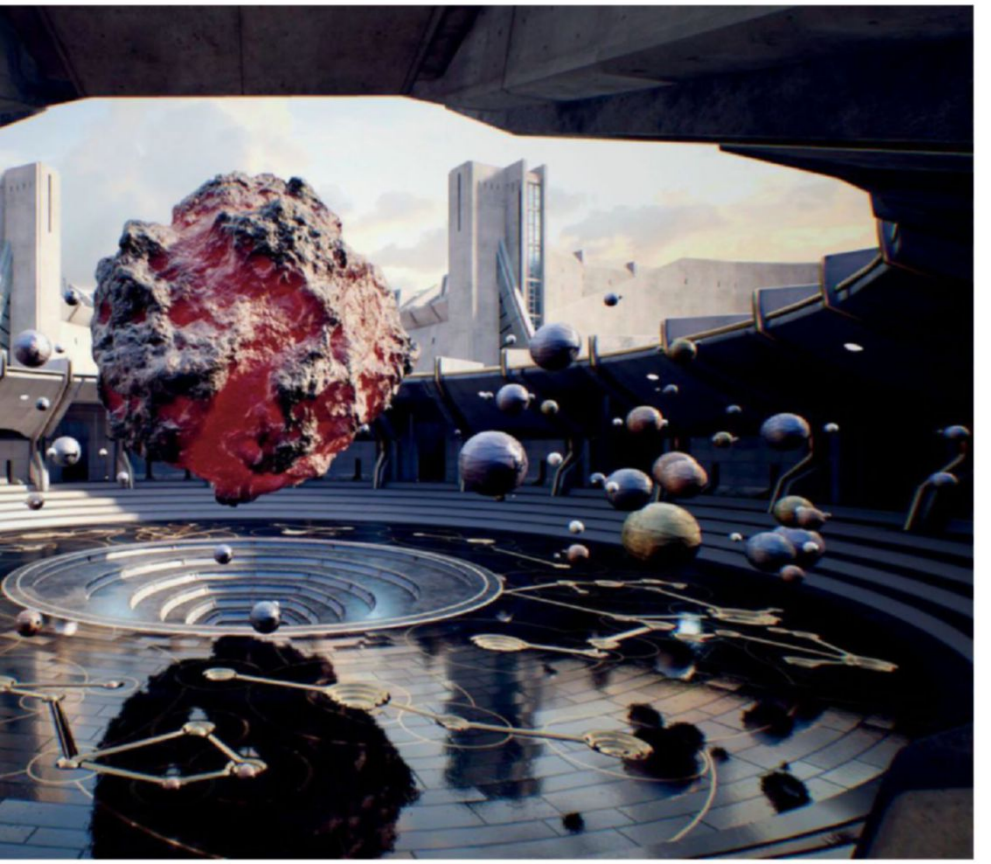
Games used to talk directly to the hardware. Your code had to know the exact register to call for everything. That's OK if you are writing for a closed platform, such as the Atari 2600, but useless on the myriad hardware combinations the PC brought. Enter the hardware driver, which routes your now mostly standardized calls to the right place. This still allows software to talk directly to hardware—not always a good idea, or efficient—but at least you only have to know one set of calls.

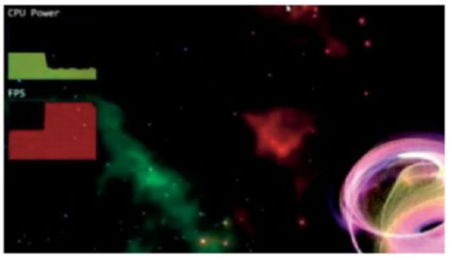
As games became more accomplished and complicated, it became increasingly awkward and time-consuming (read: expensive) to call the graphics subsystem directly from inside the game code. So, the game engine appeared and sat between the two, providing a high-level library of objects the game uses, and converting these into low-level calls to the driver via an API. Now the game coders didn't have to wrestle with the tiny nuts and bolts of generating complicated 3D, and any effort spent optimizing the game engine benefits everything.

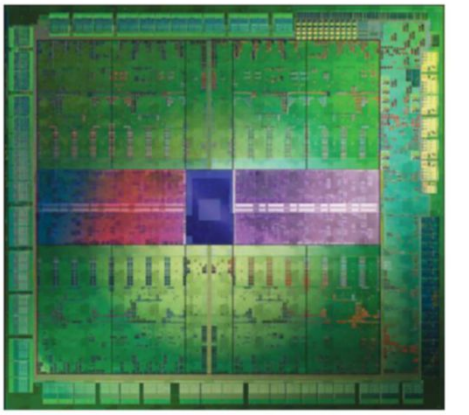
Early 3D graphics cards had proprietary APIs—remember the 3dfx Voodoo? A retrograde step, sure, but necessary to make the most of the new graphical power available. This was quickly followed by cross-platform APIs which, in theory, could work with any combination of hardware, making the most of each. This is where we are now with DirectX 11, OpenGL, and the like.

The next step is where Vulkan is treading, following Mantle and DirectX 12. The concept is to relieve the stress on the driver and smooth the path of low-level calls to the hardware, aiming for efficiency, sending code where it can be cycled at the optimum rate using all the GPU's potential. Khronos has an acronym for this: AZDO—Approaching Zero Driver Overhead.









Main image: **ProtoStar is a new Vulkan demo built using Unreal Engine 4.**
Top image: **A glimpse of things to come. The Stardust demo is a little academic perhaps, but it does highlight what a system is capable of.**
Above: **Your GPU will be able to run Vulkan.**

10 last summer. This added the batch processing of data calls within Direct3D. There was much talk of a revolutionary jump in graphics engine performance, which sometimes manifested itself, but mostly has yet to. Support has been slow, with only half a dozen games so far.

At the same time, Silicon Graphics was working on the next generation of OpenGL. This was to incorporate a similar low-level approach, targeted at getting better use of hardware for the OpenGL shading engine, with a ground-up redesign. This, along with other projects, rolled into what we now know as Vulkan. This was designed as a cross-platform API built from first principles to employ low-level code. The people behind it are the Khronos Group.

This low-level approach is far from new—consoles have been doing it for years, and all games used to hit the hardware direct from DOS. That's one reason consoles manage to get so much performance out of relatively modest hardware. What is new is dropping this sort of unified low-level hardware access on to a complicated modern OS.

We are Khronos

The Khronos Group may sound like a sinister cabal, but it's actually a non-profit consortium founded 15 years ago by some of the big players in the graphics business. It just so happens that AMD is one of the founding members, which means it brings all its code and experience with Mantle to the party—all that work wasn't wasted.

Silicon Graphics has poured its efforts into Vulkan, too. Most importantly, it contributes SPIR-V (Standard Portable Intermediate Representation). This is an intermediate language to interpret OpenGL shading language calls into more efficient low-level calls. Work and support for OpenGL will continue in parallel with Vulkan, employing much of the same technology. OpenGL was originally intended for graphics workstations, with no thought for running 3D games at all. Developments have left it cumbersome, so this new low-level layer redresses that overhead.

Nvidia is a foudning member, too. It has previously designed cards to get the most from DirectX 11 and serial processing, only to see its older cards stutter under DirectX 12 in comparison with AMD cards. With AMD and Nvidia on board, we have the two big graphics card makers in at the start, so getting early driver support is assured.

Another key player is PowerVR, a division of Imagination Technologies. It used to make full graphics cards, back when 3dfx was king. Later it moved into low-power and system-on-a-chip architectures, first for laptops and then on handheld devices, where it has flourished. You'll find a PowerVR chip in the best new smartphones and tablets, including those from Apple. This tells you one market Vulkan is aimed at, and it is a big, healthy one, too.

Despite being a Khronos member, Apple is following its own star. It has announced that its proprietary graphics API, Metal, will be in the next version of OS X, despite speculation that it would go with Vulkan. This is odd, given that it has moved to using AMD GPUs on its desktops and laptops. One of the main points of Vulkan is as a fast, cross-platform implementation of OpenGL standards. Apparently, Apple doesn't agree.

Google is on board, which means so is Android—it has promised support in the next generation of Android games. Other Khronos members include Sun Microsystems, Apple, ARM, Sony, Samsung, and Intel. It is an truly impressive line-up with representatives from all sectors. Microsoft has been part of the group since August 2014 too, although how passionate it is about Vulkan's success is certainly up for question.

Where are we now?

This is clearly an ambitious project. We are a long way from simply trying to get a few games running faster on some specific hardware combos. This is a major re-think

The key to fast 3D frame rendering is using parallel processing to shift all the draw calls.

of how graphical subsystems are employed on almost every device you can think of.

At the heart of Vulkan is the use of multiple threads to construct command buffers, which can be processed in parallel. This is the same headline-grabbing act that made Mantle interesting, but Vulkan has much more to offer. There's the native shader engine translator, better resource management, loadable layers for reduced error handling, simpler DMA queues, and many more technical features. It's going to be modular and extensible. It's going to run on everything from mobiles to consoles and desktops, with support for multiple OSes. It's going to slim down the driver, reducing its overhead, and put the full GPU power within reach of the application via the shortest and most effective route. It's also open-standard and royalty-free.

Big plans, but if all the rhetoric is to be believed, Vulkan will be everywhere. That's asking a lot, and it is still very much early days. The project has only been running for just over a year, with much of that time spent sorting out the parameters and scope. Version 1.0 of the Vulkan API specification was only nailed down in February.

An early access program has started, and the Software Development Kit has reached version 4.1. SDKs are available for Windows, Linux, and Android, all with lots of help and documentation from Khronos. Driver support on launch runs to 30 devices, including the all-important ones from AMD, Nvidia, Android 6.0, and Linux. Now we must wait while the coders try to put all that hard work to use. As yet, there is precious little to see. We have a couple of demonstrations of swirling graphics and morphing shapes, plus a bizarre field of gnomes.

How fast will it be? Impossible to say definitively just yet, but previous achievements with Mantle and DirectX 12 show that there is an awful lot to be gained if developers put in the time. There should be some serious increases in game frame rates and scene complexities.

Support from the games companies looks healthy, if a little tentative. So far, we've had positive sounds about Source 2 from Valve, Unreal Engine 4 from Epic Games, and Frostbite from EA Digital. The only developer to come through with actual running code thus far, though, is Croteam. Stardock has even reportedly called for Vulkan support on Sony's PS4—its proprietary API is seen as a stumbling block to development.

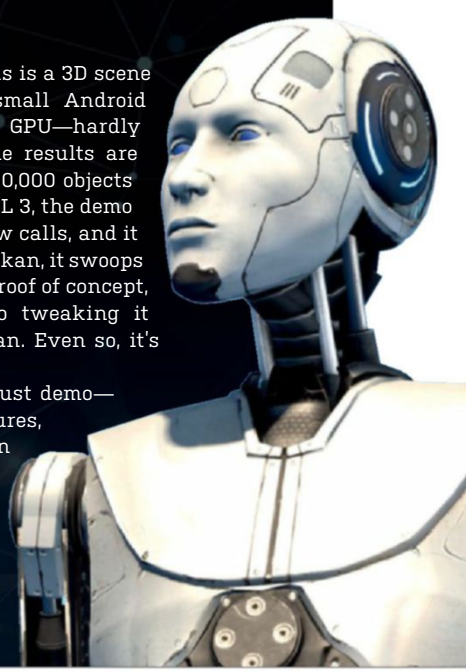
It's not all good news, though. Being low-level also means some complicated coding. Tasks previously done by the driver need to be handed over to game developers, and a lot of work on the game engines needs to be done. Initial development will be slow—it always is. Older graphics cards without OpenGL ES 3.1 or OpenGL 4.1 compatible hardware are left out, too. The biggest

Proof of concept

There is little hard evidence of Vulkan's capabilities. So far we have one game running on Vulkan—Croteam's *The Talos Principle*—using beta drivers from AMD and Nvidia. Performance is only average as the code is far from optimized. Using the integrated benchmark, Vulkan is behind DirectX 11, but faster than OpenGL. But the numbers aren't comparable, as the code paths are different and the end results can look different, too. What's more important is where it's going.

When first released, *Talos* ran faster under DirectX 9 than it did under DirectX 11. After proper optimization, it managed a 20–30 percent hike in frame rates. The developers predict a much better path under Vulkan. In fact, they've been more than impressed, stating that "Vulkan has huge potential—we've only scratched the surface of what can be done with it." And this is a game that wasn't designed to use the new fast draw call methods; it was expecting to run under a high-level serial model driver. To see this potential highlighted more directly, we have the bizarre Horde of Gnomes demo from PowerVR. This is a 3D scene running on a Nexus Player, a small Android device sporting a PowerVR G6430 GPU—hardly big league hardware. However, the results are simply stunning. The scene has 400,000 objects in it when zoomed out. Under OpenGL 3, the demo is limited by the CPU handling draw calls, and it jerks from frame to frame. Under Vulkan, it swoops through the scene smoothly. It's a proof of concept, although the developer admits to tweaking it to exaggerate the benefits of Vulkan. Even so, it's heady stuff.

Also from PowerVR is the Stardust demo—which also produces some hard figures, clocking an 89 percent increase in frame rates over OpenGL. However, it's too early to tell just how far Vulkan will push things, although it's obvious that it is going to do so, and with some gusto.



Above: **The Horde of Gnomes demo highlights how parallel processing can really produce a big difference.**
Left: The Talos Principle, **the first game to show what Vulkan is capable of.**

hurdle, of course, is convincing the industry to use it.

A lot of effort has already been put into making Vulkan developer-friendly, with plenty of translation and porting tools. Developers will be able to use it in three ways: either using Vulkan directly, or using its libraries and layers to speed up development, or using an existing game engine optimized for Vulkan. The first option could produce some excellent demos and benchmarking software, but is impractical for general use. The last option is the easiest way to the benefits without the pain. The middle path is ideal for porting existing titles with existing OpenGL support.

Will it work out?

In the world of graphics APIs, Microsoft's DirectX has been the only real player for years. Evolution tells us that two creatures existing in the same environmental niche are in competition, and that one will either evolve or die. On our beloved PCs, Vulkan and DirectX are charging straight toward each other, and it's hard to imagine that both will survive as they stand.

Vulkan is effectively the best bits of Mantle and OpenGL developments rolled into one package, with a big side order of compatibility. It's not tied to any specific hardware or operating system. It's all wonderfully flexible. There is a lot to like here.

However, you have to follow the money. Modern AAA games rival Hollywood for production costs. A huge slice of the profits from any big 3D game comes from the console sales, and here Microsoft scores with its Xbox One. It's unlikely that its latest console will ever run anything other than DirectX. Programming effort is money, and writing for two APIs, when you make most of the cash with one, is wasteful.

But Vulkan has some serious backers and loads of potential. The core concepts are sound and have established themselves as the way forward. On mobile devices, it looks to have a fairly clear run—especially given the fast turnover of hardware and software—and having PowerVR, Google, and Apple on board helps.

Getting Vulkan to be the first port of call for a graphics engine on Windows 10 will be a tougher ask, though, unless it can really push the performance boundaries and get its hooks into the game engines. What it needs is a big title to pick it up and produce something that presses gamers' buttons. However, if it does take off in all the markets it plans to, it'll leave Microsoft's DirectX 12 looking a little isolated on a single OS and a single console. Microsoft doesn't enjoy being outside the accepted standards.

What we do have here is some healthy competition to make graphics faster and more awesome. Which can only be a good thing.

DirectX

DirectX was born with Windows 95 as a set of standard multimedia APIs. Its aim was to get games to run under Windows, and not drop to DOS and use old-school direct drivers. On the development of Microsoft's first console, the term "DirectX" was coined for all these APIs. The one that interests us is Direct3D.

DirectX has had its ups and downs; version 4.0 was never even released. Newer versions sometimes struggled to be as fast as older ones, even on freshly developed games. We've reached version 12, released with Windows 10, which is the only place you'll find it outside of an Xbox One. This uses many of the low-level hardware abstraction techniques that Vulkan does. Most notably, it passes data across to the GPU in batches, rather than in single items, using multiple processor cores. This is the trick that AMD's Mantle was using and was so pleased with. For comparison, DirectX 11 ran graphics rendering on a single core.

Despite some exuberant rhetoric on launch and when the first demos were shown off, it has yet to be the game changer it was heralded as. Support runs to half a dozen games, and often with patches. We do have *Gears of War Ultimate Edition*, which works out of the box, and *Ashes of Singularity* and *Squad* on Steam. There are a few more in the pipeline but it's slim pickings. There is a long chain involved in 3D graphics, from processors through the driver and API to the game engine and then the actual game. It all takes time to sort out.

A lot also depends on the graphics card; anything optimized for the serial execution of DirectX 11, such as Nvidia's 900 series, fails to shine. Give the same job to an AMD card, and things improve. *Ashes of Singularity* proved that it can deliver under the right circumstances. It clocked a whopping 180 percent increase in frame rates given the right hardware.

TECH PO

Infin8 Toxicity Liquid-Cooled PC

BUILDING YOUR OWN CUSTOM PC tends to be a labor of love. It has a lot in common with, say, restoring an old Ford F-150 pickup truck. You can spend hours pouring over parts lists, planning your internal layout, and choosing what chassis you want to build in, before you even start on the practical side of piecing a silicon powerhouse together.

Yet it's never without problems. You're almost always bound to run into a snag, but overcoming those obstacles is exactly what's so satisfying about building your own rig. Your machine. Your baby. And the pinnacle of PC building stems from one liquifying portent: watercooling. It's an expensive addition to any rig, but what it can add to a build, well, let's just say it's undeniably beautiful. Silence-optimized machines, chilled overclocking powerhouses, and stunningly beautiful systems ready to kick some silicon ass. So, how do you achieve something like this? –**ZAK STOREY**

1 Radiator thickness

All cooling works off the same factor. Whether it's an AIO, a custom loop, an air tower, or a stock cooler, it revolves around total surface area. The more you have, the greater your cooling capacity, as more air can pass over, and cool down the coolant faster. For liquid cooling, the thicker the radiators, the more cooling potential. Make sure you've got the space.

2 Lighting

If, for you, it's all about the glam, choosing the right lighting couldn't be more important. Pro tip: Avoid LED strips in anything other than white. If you use red, for example, you'll flood your system with it, stripping out all the color the manufacturers have built into their hardware.

3 Myths

One of the biggest liquid-cooling myths out there is that it matters where you place your hardware in the loop. Thanks to the laws of thermodynamics, as long as your system is pressurized and closed, overall temperature will not change, regardless of where your hardware is placed within a build. As long as your pump is gravity-fed from a reservoir, you'll be OK.

4 Optimizing airflow

Better airflow means lower temperatures for your MOSFETs and VRMs, and more stability on your overclocks. A simple thing to do when building a new system is to remove all the hard drive cages and other unused parts. This will improve airflow, in some cases quite substantially.

STANDING ROOM ONLY

Standing desks are heralded as the healthy future for PC use, but what's the reality? *Dan Griliopoulos* finds out

Let me start by nailing my allegiances to the flagpole. I use standing desks on a daily basis. My first standing desk was homemade. Five years ago, my doctor said that my long-term back problems were a result of the amount of time I spent sitting down, and I had to reduce it. I said I simply couldn't stop sitting down, because I'm a writer. He said that I had to stop, if I wanted my back to ever get better. So I rebuilt my cheap desk using spare planks and boxes, until I had something fairly stable that was standing-only. Two years later, I moved house and dismantled it.

Now, standing desks are a standard part of many offices. It's not unusual for larger offices to offer them as an option for people who have a medical reason for using them. Some companies are more enlightened and allow anyone to request them. A recent study of Swedish call center workers revealed that 90 percent have access to such desks.

With that popularity, a huge array of companies has sprung up to provide desks. Companies such as Ergotron, Varidesk, and more supply a range of standing, sit-stand, and modular desks that range from around $150 up to $1,000 or more. (Sit-stand desks are of variable height, enabling users to switch between sitting and standing while working with the minimum amount of interruption.)

Weirder desks are less commonplace but do exist. Treadmill desks, for instance, were a trope of near-future science fiction for years before they became a mass-produced consumer object. Augmented and virtual reality will take desk design into even stranger places, because they eliminate the need for physical ergonomic designs entirely, shifting the focus to appropriately designed flooring and software that can adjust to a user's physical needs on the fly.

So why get a standing desk? Are they actually that much better for you? And if so, to whom are they best suited? Who should avoid them? And where's the best place to get them?

Why did we start sitting down to work? It seems to have been a huge mistake—talk to any physiologist and they'll bemoan this alteration in the human condition. The human body is subject to enough frailties without a compression into an unusual posture, resting on the wrong parts of the physique. A thousand problems wait to bedevil us because our bodies aren't suited to this work situation.

The first problems, and the most noticeable, come from your joints, but there are many others. Betsey Banker, the wellness manager at standing desk manufacturer Ergotron, explained more to us. "A sit-stand routine breaks up sedentary time, which we know to be harmful, and can have a positive impact on mood states, productivity, stress, and body pain, regardless of current health status. People burn more calories when standing, have increased blood flow, and greater insulin effectiveness, so it can even help manage or reverse metabolic syndrome. The key is to have a balance of sitting and standing, staying in line with the ergonomics standard of neutral posture, motion, and rest."

Medical researchers have warned that sitting for long periods is associated with poor health. The longer you spend sitting, the larger your chance of getting a whole host of illnesses. You have twice the rate of type 2 diabetes and cardiovascular disease, and a substantially increased chance of cancer and death. It's worth noting that most of these studies have been associational—that is, they haven't proved causation—but the associations are pretty horrific.

However, two recent studies did prove some health benefits. First, a team at Uppsala University in Sweden showed that "not sitting" was actually better for you than exercise (in terms of DNA damage, anyway). Second, a team in Louisiana used a huge existing database of physical activity among Canadian adults to test the effects of standing. They found that the more you stand, the less likely you are to die.

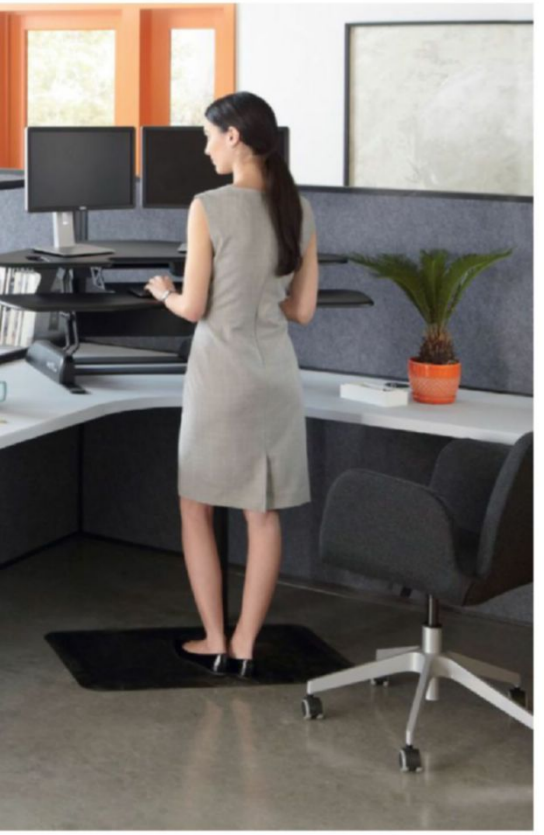
Brad Shipps, an expert at Varidesk, says, "A sit-stand desk is one of the best ways to combat what the Mayo Clinic, one of the leading medical research centers in the US, calls 'sitting disease.' There has been so much research on the dangers of 'sitting diseases' that last year the British government suggested that everyone stand at least two to four hours a day." He's right—an expert panel, convened in the UK by Public Health England, made recommendations about improving work health, which included simply standing, moving, and taking breaks for at least two hours out of a typical eight-hour day. That could be standing or walking meetings, pacing, taking calls standing, using the stairs, walking over to talk to colleagues rather than emailing, and actually taking your darn lunch break.

Above: **Specialized standing surfaces aren't necessary but are recommended.** ***Left:*** **A clamped sit-stand desk is hugely flexible.**

DON'T TAKE IT LYING DOWN

Of course, standing desks can help with a lot of this, as well. There are secondary advantages, too. "Using a sit-stand desk is also a means to increase daily low-level physical activity, which is important to our health," says Banker. "Low-level activities, also known as NEAT (non-exercise activity thermogenesis), can even have a greater impact on overall daily calorie expenditure than exercise."

On top of that, some studies have shown that productivity improves as much as 15 percent when people are standing. "A workstation that changes positions in 10 seconds or less allows the user to sit or stand as needed, without interfering with workflow," says Banker. "The ability to change positions easily, without interruption to thought processes, aids productivity in the workplace, and studies in education do



link greater user focus and engagement to the introduction of stand-biased desks.

"Some of this is anecdotal, but we do hear about people claiming they are sleeping better, feeling more energized throughout the day, and are even making better choices about other exercise they do during their day, or what food they eat. There is a tendency to be more prone to recognizing other sedentary parts of the day, and to start making changes to break that up, too, like TV-watching or computer time at home. Or when out and about, like standing at a tall table at the pub versus sitting on the stool."

Starting to use a sit-stand or standing desk can be a slow process. Listening to your body is key. It gives clues as to when it is getting tired in either seated or standing positions: muscles start to ache, fidgeting begins, distraction sets in, or comfort is elusive. These are all signs it might make sense to change positions. "Once someone is into a routine, they may discover that certain tasks relate to sitting versus standing," says Banker. "By understanding how your energy flags throughout the day, using the workstation to monitor energy is a good idea. For instance, after lunch, stand in the afternoon to fight off sleepiness. The same is true for meetings." Challenges with co-workers or software tools can help maintain motivation, as can remembering why you're standing more!

STANDS TO REASON

So which desk should you choose? There is a variety of desks you can buy. The simplest are cheap desktop units that sit on top of other desks. Ergotron, Startech, and Varidesk all supply such units. Whatever your physique, it's worth using a calculator to work out the dimensions of the desk you'll need. Ergotron has a simple interactive one at http://planner.ergotron.com.

If you're taller, your choices are more limited. You need a high-rising leg system on the desk that has minimal wobble at full extension. For example, Ergo Depot's Jarvis can accommodate people up to 6' 7"—half a foot higher than most desks can manage.

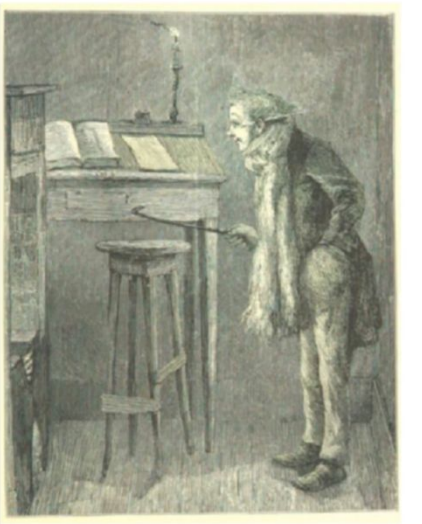
The Jarvis is also motorized, unlike many desks, which use counterbalances. Motorized desks are easy to use, but can be slow. The lighter Jarvis Bamboo, for example, takes 20 seconds to extend, rather than almost instantly with counterbalanced desks, as Shipps points out: "With a manual adjustment desk, there's nothing to program or plug in. But it still has to be easy to raise and lower. That's why we designed the Varidesk with a spring-loaded boost mechanism, so that even with a fully loaded desk, users of any height or fitness level can go up or down in just a few seconds."

"Certainly, mechanical desks also offer smooth up or down motion," agrees Banker. "But one has to accommodate the transition time interruption that you don't find in counterbalanced desks. Instant change from sitting to standing minimizes interruption." Motorized units also have preset heights they can extend to—not great if your comfort zone is between them.

That said, many counterbalanced desks need adjusting to reach the right tension. "Fully understanding the adjustability is a wise step," advises Banker. "Most products have tension to counterbalance the weight of the electronics and make lifting and lowering easy, so you'll want to tension your product until it goes up and down easily."

What's noticeable is that many standing desks have metallic or plastic finishes—

> "The longer you spend sitting, the larger the chance of getting a whole host of illnesses."



© Image courtesy of the British Library

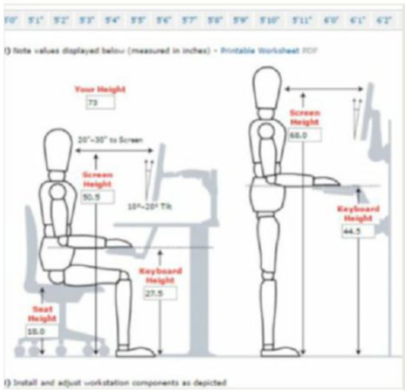
UPSTANDING HISTORY

Historically, it was normal for people to read standing up. If you look at old photos of 19th century offices, or engravings like the one above (from *A Christmas Carol*, depicting Bob Cratchett's workspace), you'll see that it was quite usual for workers to stand up to work—a sloping desk enabled them to bend over their work more easily. An 1858 self-help book pointed out that standing desks supported "nearly half" of all business writing.

Go further back, and it was still normal practice to read standing up. Look in an old chapel and you'll see the priest's lectern, a hangover from that era. Famous men of history—Dickens, Churchill, Jefferson, Rilke, and Da Vinci—also used standing desks for writing, proofing, reading, and designing. Indeed, draftsmen today often use desks that are very similar to those from that era.

So, why and when did we start sitting down? Looking at the frequency of the phrase in books (using Google's essential Ngram viewer tool), there's a pretty clear decline in the mentions of standing desks, from a large peak in the 1890s to the early 2000s, when there's a resurgence.

By the 1950s, when Hemingway was still using a home-made standing desk, it was seen as an anachronism—when the sports journalist George Plimpton visited him, he saw a "perfectly suitable desk in the other alcove" from Hemingway's typewriter, which was atop a bookcase. Perhaps it was the post-war era of mass production and molded furniture that finally killed them off—the larger, lower, office desk, with its easy chair, may have been a symbol of luxury, which mass-produced materials made affordable to the majority of people. Certainly, by the 1960s, they were long gone.



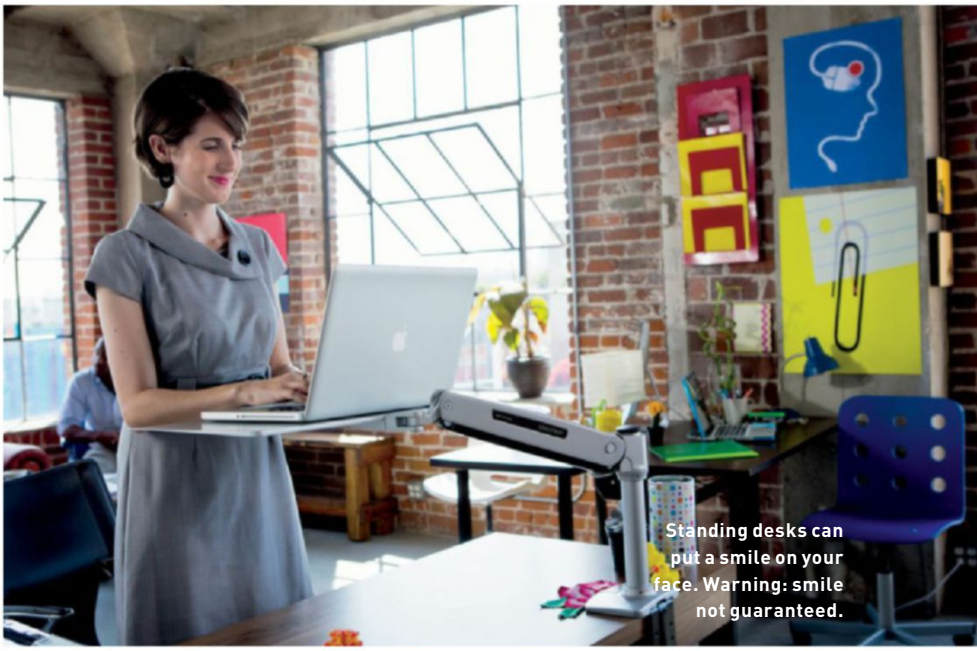
THE BODGE

Building your own standing desk is easy. We recommend starting with a basic, cheap desk—if it has a raised back, all the better to support the monitor. For example, the Ikea Fredde and Micke desks both have good shelved backs. Then it's a simple case of taking sturdy boxes, planks, or large books and fixing them down, so there's a platform for your keyboard to sit upon.

And do pay attention to our experts' advice. Varidesk's Shipp has no problem with home-made desks. "First, I've got to say that I'm impressed with some of the ingenuity and imagination I've seen in the DIY standing desks. But I'm not always sure how safe they are, and very few of them are adjustable. A Varidesk is adjustable, comes fully assembled, sits on top of almost any desk, and has our 30-day no-risk guarantee. Also, you aren't locked into just one position all day."

Banker agrees: "Home-made versions frequently lack even basic ergonomic features for wrists, shoulders, and neck—not surprising when many are made from empty boxes or crates. Ergotron, for example, designs products with user ergonomics in mind, taking into account keyboard and monitor positioning, and height-adjustability, to meet 95 percent of the users for an overall better working experience. When creating a hand-made option, using a simple calculator like Planner.ergotron.com helps work through important ergonomic considerations."

Two things are essential for the desk to be adjusted correctly. Firstly, the top of your monitor should sit roughly at eye level, so you're not craning your neck up at it or bending down. If this is incorrect, your posture suffers, and your back curves unnecessarily, at either your shoulders or lower spine. Secondly, your hands need to be resting flat on your keyboard, not stretched up or down. This prevents RSI. That means your keyboard should be at the same height as your hands, while your forearms should be parallel to the ground.



Standing desks can put a smile on your face. Warning: smile not guaranteed.

especially those intended for a mass-purchase office environment. Most don't match up to the beautiful designer or antique desks you can buy, often for less than the price of a sit-stand model.

That said, because they're not attractive, customizing them won't make them look worse. Adding extra monitor mounts or an adjustable keyboard tray are common options. And be aware that you'll probably need longer cables for all your gear.

What would Banker choose? Well, she has a message to send: A well-designed sit-stand desk is superior to any other type, especially a home-brew one. But she does make some good points: "The ergonomics and adjustability are clear differentiators between home-made solutions and pre-built. Often, people only have the means of building a fixed-height standing desk on their own, which sacrifices the ability to regularly switch positions, or may require a change to a tall stool or chair."

Indeed, in the case of my home-brew desk, I could only manage a couple of hours a day to start with. I bought an old bar stool to perch on when I got tired—if you want something similar, try searching for an artist's stool or drafting chair. This was an effective way to use my home-brew desk without working out a way to make it raise and lower—but I found myself sitting on it more than I was standing.

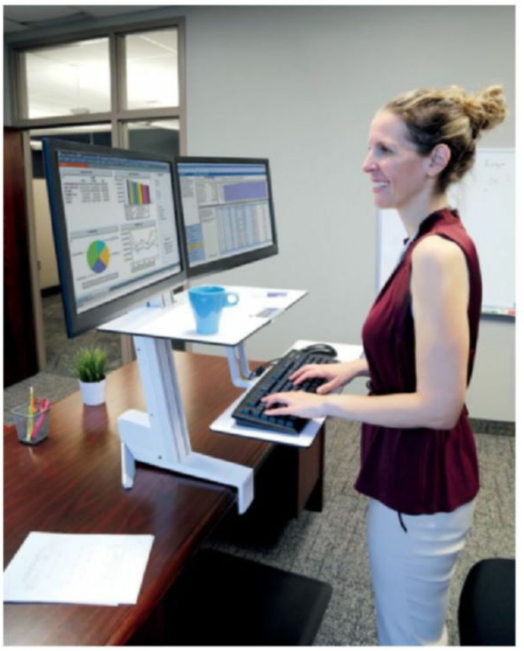
Not that fixed-height desks *per se* are problematic. "To a certain extent, if the fixed-height situation is customized to the individual user, and a tall stool or chair is deployed, this is a viable solution. Especially when starting out, going from 100 percent sitting to 100 percent standing is hard on the body," says Banker. "A common approach is to gradually introduce more standing into the day over time. For example, start with 10 minutes an hour during the first week. The gradual transition allows time for the body to adjust, as muscles are now being active that had previously been underused."

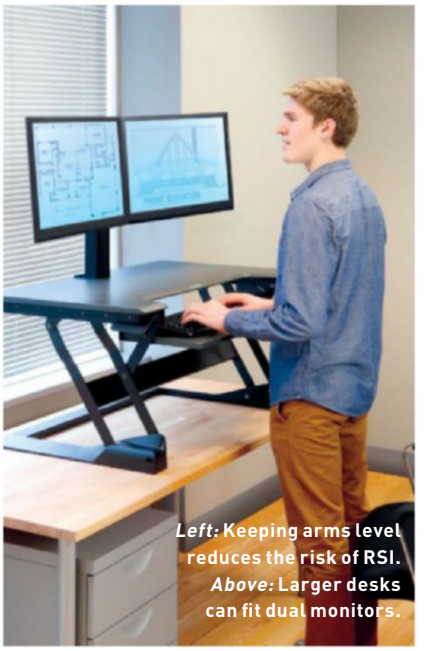
You should also consider the comfort of your feet, considering how much extra strain they'll be taking. Shipps recommends standing on a support mat: "Most people find that using a cushioned anti-fatigue mat is the way to go—especially on hard floors like tiles or concrete. They make a huge difference to improve the comfort for your feet, legs, and back." For new users, Banker recommends wearing comfortable shoes, and for women, shoes with low heels, so that no matter what floor surface, feet and leg stress will be minimized.

Are there groups that particularly benefit from standing desks? Well, I have sciatica—a form of severe back pain that's aggravated by sitting for extended periods. Sit-stand desks are great for me, providing I use them in accordance with the advice of a health-care practitioner.

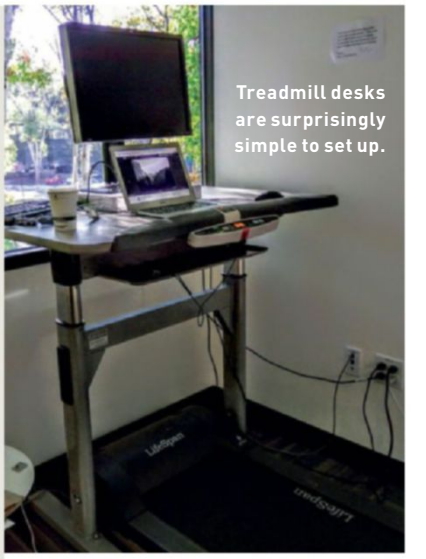
"Research indicates that sit-stand may reduce current back and neck pain, so it's likely that someone with back pain will actually find relief," says Banker "Stanford University just released a study that showed that access to sit-stand workstations began making a difference for workers after about 15 days.... Some businesses use sit-stand workstations as a prescriptive solution for employees experiencing significant pain, like lower back pain."

People with back problems do need to take particular care—motorized or well-





Left: **Keeping arms level reduces the risk of RSI.**
Above: **Larger desks can fit dual monitors.**



Treadmill desks are surprisingly simple to set up.

©Travis Wise

counterbalanced units are important. "Finding a solution that does not put additional force on the body is key," says Banker. "Look for units with easy height adjustability and proper ergonomics (being able to raise and lower the desk without having to reach far away from the body or use high levels of force). People may also want to consider using a foot stool to prop up one foot when standing, as it relieves pressure on the lower back."

Not that standing desks are solely for the infirm—as we said, they have health and productivity benefits for workers of all capabilities and ages. Indeed, Banker points out that many businesses with sedentary workers, such as call centers, consider adopting sit-stand desks across that entire division. "Office workers are a big market, but Ergotron is seeing students responding very favorably to adjustable desks as well. Kids as young as fourth grade understand and positively respond to their body's need to move more. We also see what some consider 'the worried wealthy,' who are looking for proactive means to manage their health, and like the added calorie burn and energy boost moving more at work affords."

That sounds dangerously like a fad—albeit one that's been going on for a few centuries, as Shipps points out: "Considering that Churchill, Hemingway, and Thomas Jefferson all used standing desks, that would be the oldest fad I've ever heard of! With all the research coming out about how dangerous it is to be sedentary, I can't imagine us going back to sitting at our desks all day. That would be like everyone starting to smoke cigarettes again."

This latest incarnation has only been around for five years, though, and may fade out again as people remember how lovely a nice sit-down is. But what's more likely is that it'll spread to more businesses and homes, as people understand how healthy it is. Banker calls it a "workplace revolution of sorts," as businesses take environments that promote the health and wellbeing of their workers more seriously: "Even global health organizations are weighing in on how to best help business break up sedentary time for workers, such as the World Health Organization, which identifies physical inactivity as the fourth leading risk factor for global mortality. We live in a technological age, where many jobs are computer based, so adding physical activity is imperative to our health and sustainability."

> "Going back to sitting at desks all day would be like everyone starting to smoke again."

Despite all the benefits of standing desks, Ergotron's JustStand Index shows that only seven percent of the US public are aware of the problems associated with sitting. Raising that number and returning the population to the health benefits that our grandparents enjoyed is a simple step. We just need to take a stand.

BEYOND STANDING

Treadmill desks are the logical extension of the standing desk concept. If standing is so good for you because it enables you to move around, goes the thought, then running must be super-healthy. And, although a lifelong user of standing desks—such as Donald Rumsfeld, say—no longer feels tired after 10 hours of standing, for most people, just standing for an hour can be exhausting.

However, there are problems. Walking while typing is a difficult skill to learn at first. Meanwhile, many treadmill desks don't even come with a treadmill—and some specialized treadmills are sold without a desk! On top of that, most of them are pretty ugly or badly designed. This is probably because the industry is still at an early stage, and most desks are just generic, mass-produced ones.

We can recommend TrekDesk's desktops, though. Although they're not comely and come without a treadmill, they're very cheap—around $400—and you can pick up a small treadmill for another $200–$300. At the other end of the market, LifeSpan's integrated treadmill desks are robust, attractive to look at, and full of useful features, such as integrated Bluetooth, which can report your exercise to health apps—but they are rather expensive, ranging from $800 to $3,000.

If you're thinking of buying a treadmill desk, test it out first. Ensure that the treadmill has a good top speed, is wide enough for wandering feet, and the motor isn't too noisy. Check that the desk is robust, with easy-to-access handholds to support you when you need to take a break. If you're willing to pay a little more, invest in a treadmill that doesn't need lubricating every few months.

MAKE FLAWLESS BACKUPS

Protect your precious data from any disaster, instructs *Nick Peers*

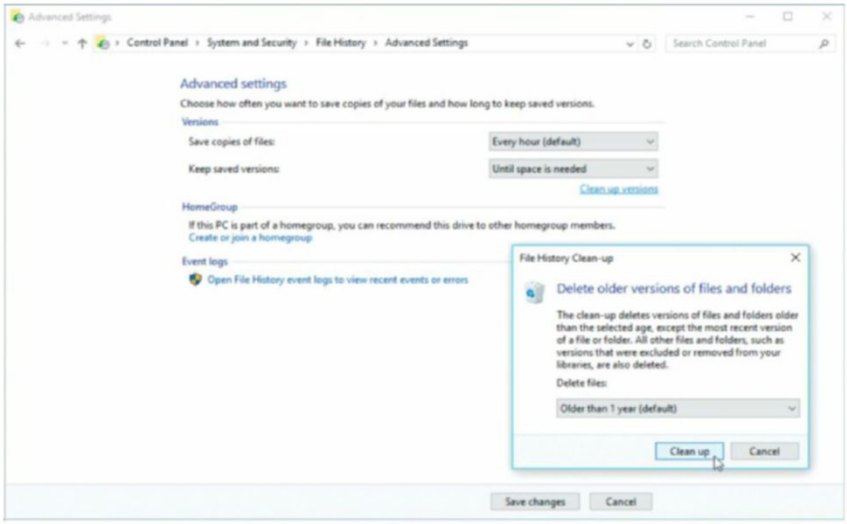
Backups may not be the sexiest of subjects, but you'll want to take yours for a candlelit dinner the day it turns a data recovery disaster into a minor annoyance. Think for a moment: how much is your data worth? Some files are more valuable than others: for some, it's the time taken to recreate a document, while others—such as photos and videos—can never be brought back.

Most people know the importance of backing up, but can you be sure your backup plan is up to scratch? Many people keep one backup copy of their files, but what happens if it is destroyed along with the original? Seeing as most people keep their backup drive in the same location as their PC, that's not a fanciful notion.

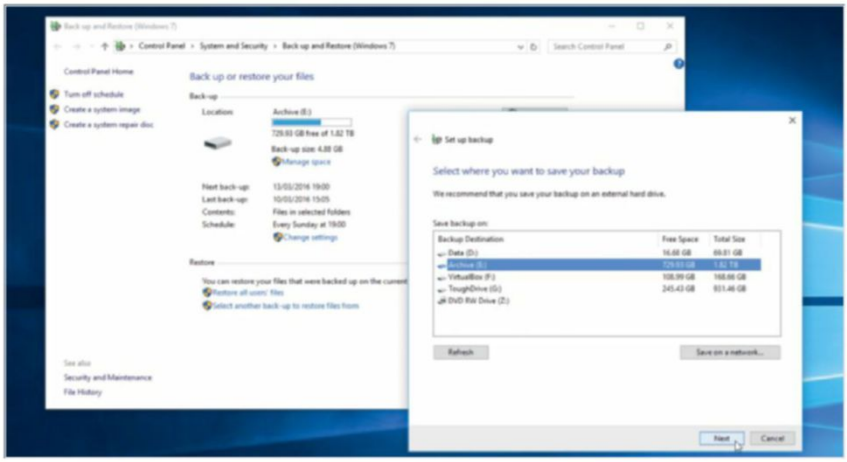
We're going to help you create a multi-layered backup of your data, ensuring it's stored in at least two separate locations, and preferably more. We'll reveal the best tools to use—both Windows' own backup tools, as well as great third-party tools. We'll also look at backing up your entire system drive, so if you run into problems, you can roll back to a working Windows installation without having to reinstall.

These days, keeping at least one backup in a remote location usually means taking advantage of cloud-based services, such as Dropbox or Microsoft's OneDrive. There are many potential issues with relying on third parties, whether it's security, constantly changing pricing plans, or what happens to your data if the company ceases trading. If these are deal-breakers for you, we'll look into alternatives, from sharing backup space with trusted family members to setting up your own encrypted cloud storage, where you have no worries about monthly subscriptions.

We'll also make sure you know what to do should disaster strike and you need to restore a copy of your data. Without further ado, then, let's get backed up!



Make File History your first port of call.



Windows 7's Backup and Restore is available in Windows 10.

Select your backup device

When it comes to choosing where to back up your files to, you're spoiled for choice. But it's not a case of either this backup device or that one— ideally, you should invest in at least two separate devices. Here's what to look for.

Secondary hard drive: this can be internal or external (USB). Use it for your primary file and drive image backups, using Windows' own tools and Macrium Reflect Free.

Network hard drive: a good secondary solution that can be kept elsewhere in your home for added security. Perfect for any of the backup methods we discuss here—you can even use it as the basis for your own personal cloud storage system using OwnCloud.

Other computer: if you own another PC (or Mac), keep your key files in sync on all your computers using a cloud storage service or Syncthing. As an added bonus, the latest version of your data is always available to whichever PC you're using.

Friend's or family computer: you can swap unused storage space with people you trust, but make sure your data is kept in an encrypted format on their computer—use Buddy Backup or Viivo in conjunction with Syncthing.

Cloud storage: if you have a fast, unlimited Internet connection, using a trusted service such as Dropbox, Microsoft OneDrive, or Google Drive is also an option. Again, use Viivo to encrypt sensitive data for extra security.

Synology's DS216+ network drive is a great backup device.

You may already have a basic backup plan in place—Windows 10 makes this easy by offering you a choice of two routes, including both Backup and Restore from Windows 7, and File History from Windows 8. They're easy to access and set up—search the "Start" menu or Cortana for "backup." Both focus on producing backups of key documents, photos, and other personal data, and can back up to any drive that's visible to your PC, including network attached storage.

Rule one of our backup strategy is to make use of multiple backup locations (see "Select your backup device," below-left). Neither File History nor Backup and Restore allow you to back up to alternate locations, but if you're running Windows 10, you can employ both together to get around this restriction. Configure File History to back up to one location—we recommend a drive physically attached to your PC—and use Backup and Restore to back up to another drive, preferably a shared folder on your network drive. File History constantly monitors for changes and backs up as necessary, while you should schedule Backup and Restore to run weekly at a time that won't interfere with your PC use—say, lunchtime on the weekend.

System backups

Your data is taken care of, but what about Windows? If disaster strikes, you could find yourself spending days getting your PC set up again—but if you take a full system backup (known as a "drive image"), you can have your PC up and running again within an hour. Windows offers to create a system image when you set up Backup and Restore, but there are weaknesses. First, each backup requires tens of gigabytes of space on your PC. Second, images aren't verified when they're created, so you've no way of knowing if you can rely on them. And third, images are only stored on a single drive.

Eliminate all three weaknesses by employing the services of our favorite drive-imaging tool, Macrium Reflect. We've used it to back up (and rescue) Windows countless times over the past five years, and nothing comes close to it. Start with the powerful Free version at www.macrium.com/reflectfree.asp, which solves the issue with space by using differential images that take up much less room by only recording the changes made since the last backup was taken.

Launch Macrium Reflect Free once installed, and click

"Create an image of the partition(s) required to backup and restore Windows." Next, set your destination—a folder on your backup drive. You might want to change the file name to something more easily recognizable, and take the time to click "Advanced Options" to select "Auto Verify Image" to ensure your backup is checked for errors after it's been taken. Once done, pick a backup schedule—we recommended pairing one monthly full backup with weekly differential backups, or choosing the "Differential Backup Set" template for more frequent daily backups. Click "Next" followed by "Finish."

In the spirit of data redundancy, you should then repeat the process, creating a second definition rule pointing toward your secondary backup drive—speed things up by right-clicking the rule you just created and choosing "Duplicate." Don't forget to create the rescue media (DVD or 4GB USB flash drive) when prompted by Macrium—this ensures you'll be able to restore your system even if Windows won't boot.

If you want more features—including incremental backups, and the ability to back up files and folders—upgrade to Macrium Reflect Home Edition for a one-off $69.95.

The power of the cloud

These days, backups are synonymous with the word "cloud," the logic being that storing backups in the cloud ensures one copy of your data is kept off-site in a secure location in case of fire, theft, or worse. It makes sense, although there are some drawbacks (see below). The obvious choice when backing up to the cloud is to employ a known solution—Microsoft's OneDrive service is baked into Windows 10, but alternate trusted sources include Dropbox (www.dropbox.com) and Google Drive (https://drive.google.com).

Each service offers limited free plans of around 5–15GB of free storage space, which is fine for personal files, such as documents, photos, and even some video, but if you run out of space, you'll need to upgrade to a monthly or annual subscription. One of the best value solutions is to install Office 365 for $9.99 a month or $99.99 a year—your subscription includes 1TB of cloud storage as well as access to the latest version of Microsoft Office for up to five users.

However, there are some reasons to treat cloud storage with suspicion. These include ongoing costs, the security of your data, and what happens if the company in question either goes out of business or discontinues its product, as users of Wuala and AVG LiveKive cloud storage services have discovered to their cost over the years.

In terms of fees, consider prioritizing what data you store in the cloud—do you need your videos backed up online, for example? As you have a local backup in place, you could focus on storing important documents and photos in the cloud, where you're unlikely to run out of space quickly. That way, you can usually get away with free storage plans.

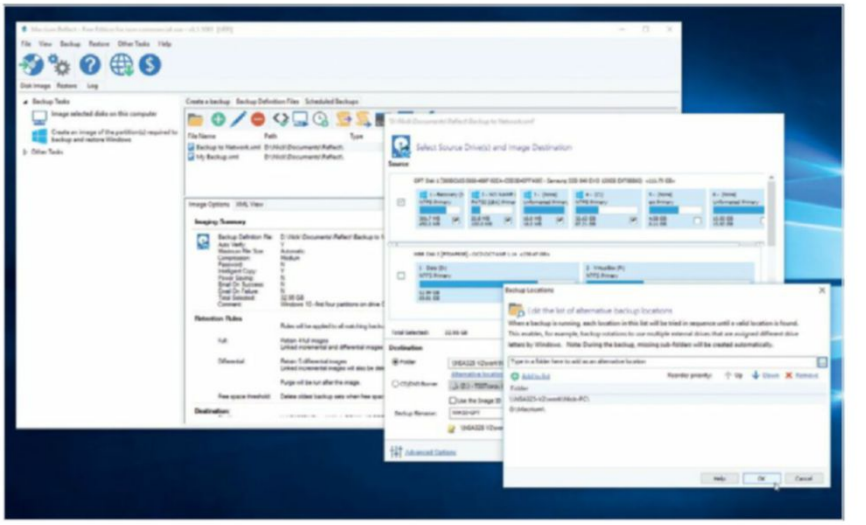
If you don't trust your cloud provider's encryption, add a secondary layer of encryption to sensitive files before uploading them to the cloud. The best tool for this purpose is Viivo (https://viivo.com), which works with multiple cloud providers, and includes tools for sharing access to files with trusted family and friends. It's free for personal use, but make sure you keep a separate, unencrypted backup of this data somewhere safe, too, to ensure you're not locked out of your files for any reason.

Alternate strategies

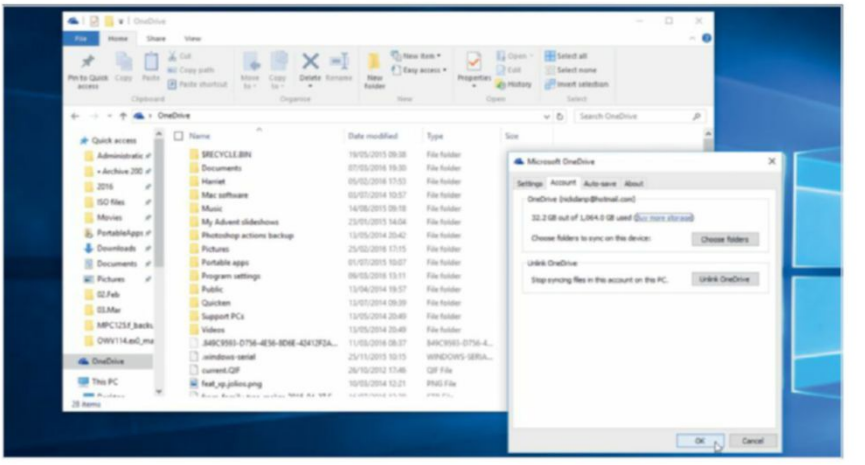
There are two principal alternatives to putting your data in the hands of a third-party provider. Both can be used over the Internet if you have a fast and unmetered connection, but you can also use them exclusively over your local network, too, ensuring your data never touches the cloud in any shape or form.

The first of these options involves synching data from selected folders directly between two or more computers. It works beautifully over your local network, as well as the wider Internet, if necessary. It's perfect for keeping files in sync between computers you own, and creates an exact copy of your files, so there are no issues with proprietary file formats. Naturally, the connection is encrypted, and the software is open source.

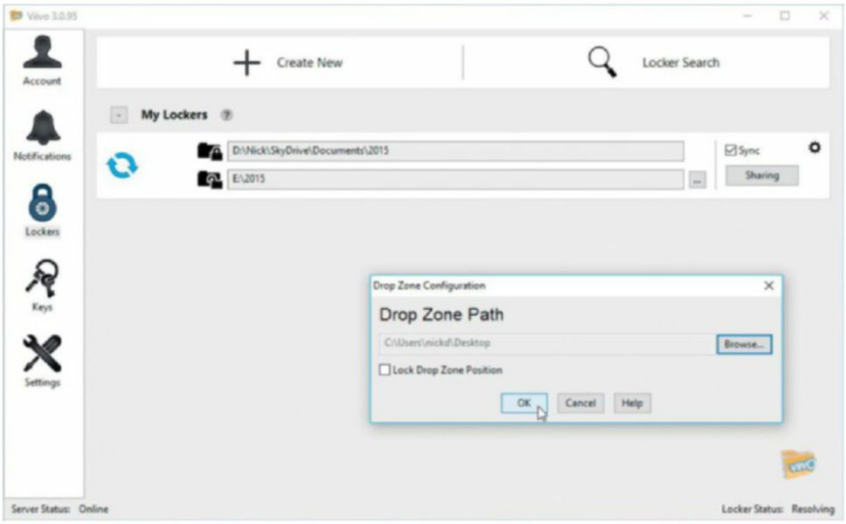
The program in question is called Syncthing, and it works across Windows, Linux, and Mac, and can even be directly installed to selected network drives. We recommend installing the GTK build from https://github.com/syncthing/syncthing-gtk—install it on both computers, then select the folder you wish to sync on your main computer, before connecting it and your other PC together. Once done, the files are kept in sync automatically whenever



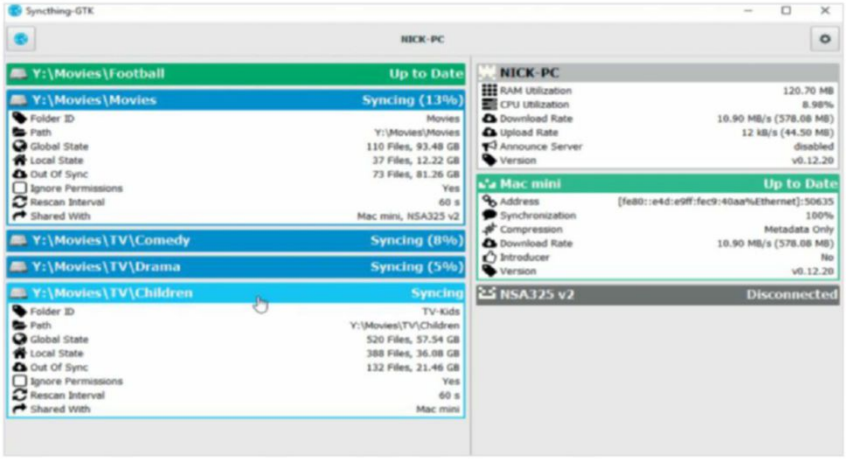
We've trusted Macrium for over five years.



Microsoft's OneDrive offers a remote backup solution.



Worried about sensitive data? Viivo adds more encryption.



Keep data synched (and backed up) across all your PCs with Syncthing.

Syncthing runs—configure it to start with Windows, to ensure it's always backing up.

Files are transferred directly between computers, so they both need to be on and connected for files to sync. If you wanted to store backups remotely on friends' and family's PCs, take a look at BuddyBackup (www.buddybackup.com), which encrypts your data so it's unreadable on the computers you back it up to.

Your personal cloud

If you'd like to store files centrally (creating an additional backup of your files in the process), without relying on a third party, then set up your own using a spare PC or network hard drive as the file server.

Some network drives come with their own proprietary cloud systems—My Cloud from Western Digital, for example—but we recommend choosing something open source and more widely supported: OwnCloud (https://owncloud.org), which works across a variety of platforms. The server part can be installed to many network drives—including Zyxel and Synology (the latter via https://synocommunity.com)—as well as Linux-powered PCs, including the Raspberry Pi 2, if you're looking for a low-cost solution. You then download and install the desktop and mobile clients on Windows, Mac, Linux, Android, iOS, and other supported platforms, to allow you to both sync and access your files from anywhere.

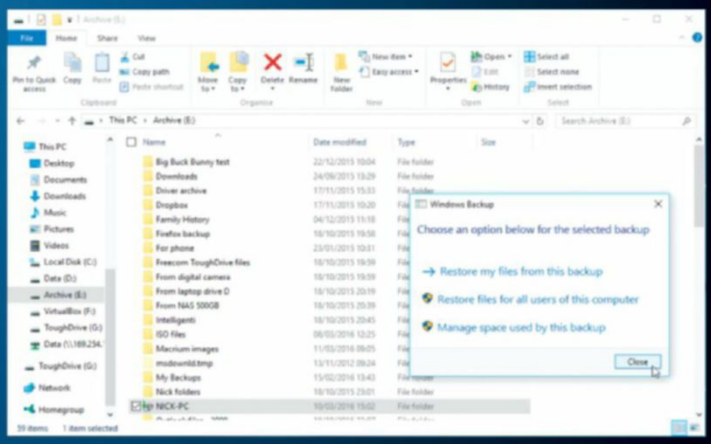
Think of OwnCloud as being your own personal cloud storage system—you're not tied to any third parties, there are no monthly fees to pay for storage, and your cloud can be restricted to your local network

Protect your backups

Nothing lasts forever—and the same is true of backups. Optical discs don't last a lifetime, as we once thought, while hard drives physically wear out, and cloud storage can disappear without warning. That's why backing up to multiple locations is essential, but it doesn't stop there. You should take additional steps to protect your data from physical degradation.

Check with the maker of your drive for a monitoring tool, such as Seagate's SeaTools (www.seagate.com/seatools), to keep an eye on your drives' health, giving you time to replace failing drives before they disappear with your data. If you want a network drive, choose a two-bay model, such as Synology's DiskStation 216+, and fill it with two identical drives in a RAID 1 setup. Data is mirrored on both drives, so if one fails, you can swap it out with a replacement without fear of data loss. Just remember a RAID array doesn't constitute two backups—if the enclosure fries (or gets stolen), you lose both drives. (As an aside, try the free DMDE data recovery tool from www.dmde.com if you need to recover data from NAS-formatted drives.)

Also watch the software you use. Some tools store your data in their own proprietary formats, so if the software stops working (perhaps after upgrading to an unsupported version of Windows), you lose access to your backup. Both Windows backup tools use their own format, as does Macrium, Backup Buddy, and Viivo (as part of protecting backups through encryption). So, make sure one of your backup plans simply duplicates your files in their original format to ensure you have one easily recoverable version of your files—Syncthing, OwnCloud, and other cloud storage providers all do this.



You can't recover files directly from Windows backups.

or opened up securely for access over the Internet, should you need it. It works with multiple users, too, so everyone in your household gets their own secure storage space (with quotas to limit individuals from hogging the drive for their own files).

Some initial configuration is required, but everything's point-and-click, with a useful manual on hand to steer you in the right direction. One tip: When asked to set up your initial account, be sure to click "Storage & database" to select the MySQL option, rather than the default SQLite one. This will dramatically speed up the server's performance when it comes to synching large batches of files.

Restoring from backups

Disaster has struck—you've lost data for one reason or another, so what next? Thanks to your backup plan, you should find you're able to quickly and relatively painlessly restore the data you lost. If you've used File History, navigate to the folder with the missing data in File Explorer, and click the "History" button on the "File" tab.

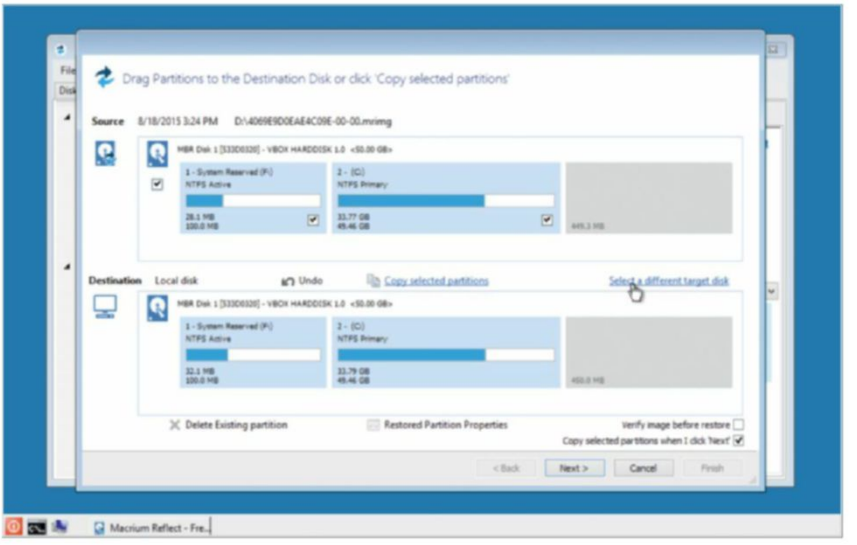
A window opens displaying all the backed-up files in that folder—double-click the missing file to preview it, then click the "Settings" button and choose "Restore" to save it to the current location, or "Restore to" to save it elsewhere. If you're trying to recover an earlier version of a file, use the left and right buttons at the bottom of the page to navigate between available versions, until you find what you need.

If you're recovering from Backup and Restore, browse to the drive or folder containing your backup, then double-click it and choose "Restore my files from this backup." Click "Choose a different date" if you're looking for older versions of your files, or use the search and browse buttons to locate what you want to restore. You can restore them to their original location, or choose another—make sure you leave "Restore the files to their original subfolders" ticked to preserve the original folder structure, before clicking "Restore."

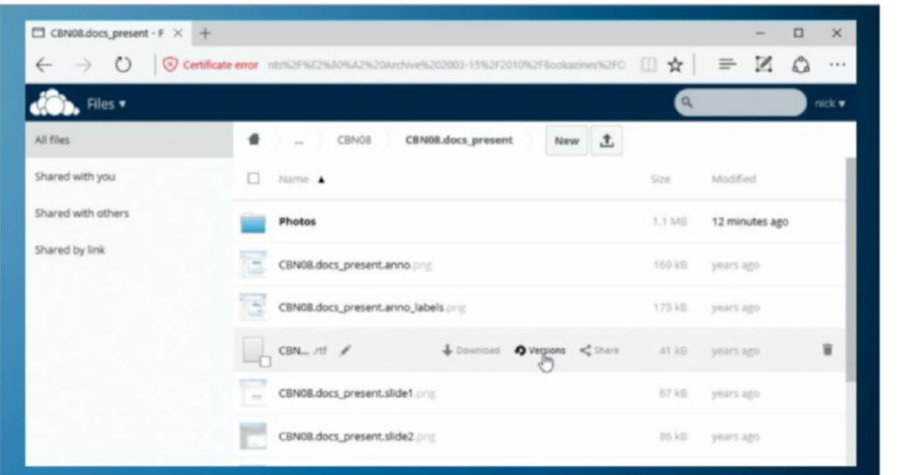
Need to recover your entire PC? Macrium Reflect makes things straightforward: If you can boot into Windows, launch the app and switch to the "Restore" tab; otherwise, boot from your rescue media. Either select the backup you want to roll back to from the list given, or click "Browse for an image file" to locate it manually. Select "Restore Image" to restore the full image, or choose "Browse Image" to mount the image as a virtual drive, enabling you to browse it as a virtual drive in Windows itself—a good option for recovering individual files and folders from the backup. Make sure you tick "Enable access to restricted folders" to allow you to recover data from user folders and other protected places.

Restoring files from the cloud isn't usually an issue, because everything's kept in sync, but if you need to restore a file you've accidentally deleted, then taking OneDrive as an example, log into your OneDrive account through your browser. Click the ≡ button and select "Recycle bin" under your PC's entry to see if it's still recoverable.

Recovering data from OwnCloud is simple, too—when you reinstall the software and log in as your own user, you're prompted to choose which folder on your hard drive to store your OneDrive content on—once done, the folder syncs up with what's online, restoring any missing data, or you can log on through your browser to download individual files if necessary.



Restore your PC even when it won't boot with Macrium Reflect.



Back up file revisions

One of the fringe benefits of following our backup plan is that many of the tools on offer record multiple versions of your files, enabling you to undo changes to files as well as restore lost, deleted, or corrupt data. Both Windows backup tools support this, although File History's default settings of updating your files every hour (rather than weekly, as with the Backup and Restore tool) means you have greater flexibility.

If you back up files to OneDrive, Dropbox, or your own OwnCloud server, access your account through your web browser, then locate the file in question. OwnCloud users should click the "Versions" option next to the filename; otherwise, right-click the file and choose the option to restore a previous version, to see what's available based on time and date. You can often preview earlier revisions by clicking them.

Syncthing only stores one revision of a file by default, but you can change this on a folder-by-folder basis. Right-click the folder bar in Syncthing-GTK, and choose "Edit," then select an option from the "File Versioning" menu—each has a description, and you get context-sensitive options, such as the number of versions to keep.

One caveat: storing multiple versions of files requires more space than straight one-to-one backups. Bear this in mind when choosing what size hard drive to buy.

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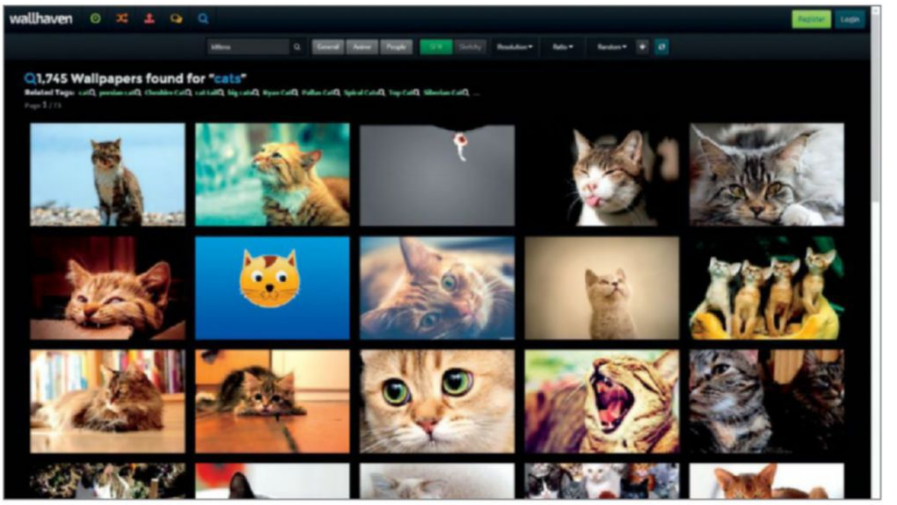
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

WINDOWS TIP OF THE MONTH



FIND THE PERFECT WALLPAPER

Hunting for the perfect desktop background is a pain. Trying to trawl through Google's image search is a nightmare, and places such as DeviantArt, although housing some fine masterpieces, are generally filled with a lot of poorly drawn cartoons. Ladies and gents, we give you www.wallhaven.cc. You can search by resolution, color, aspect ratio, you name it. Then it's just a case of left-clicking the image you want, right-clicking it in the new window, and then saving to desktop.

MAKE – USE – CREATE

66
Create 3D graphics with Python and Pi3D

70
Blend images to create star trails using Photoshop

72
Control the internal airflow within your chassis

ZAK STOREY
STAFF WRITER

WATER-COOLING WOES

Liquid cooling. It's by far the most prestigious part of building a custom PC. To do it properly, it's often ludicrously expensive, quite troublesome (certainly for the average techie), and requires yearly maintenance to ensure your coolant doesn't turn to gloop in the process. The biggest question—or criticism—we receive when writing articles about this impressive art form is, "Why bother? You don't need it."

Yeah, we know. We get it. Of course you don't need it—it's not about need. No one needs to liquid-cool a PC, just as no one needs a nice new smartphone, or no one needs a bespoke suit, or a brand-new car. It's about want. In theory, you could get away with just using a stock cooler with a stock CPU, but in reality, that's just not appropriate for what we do.

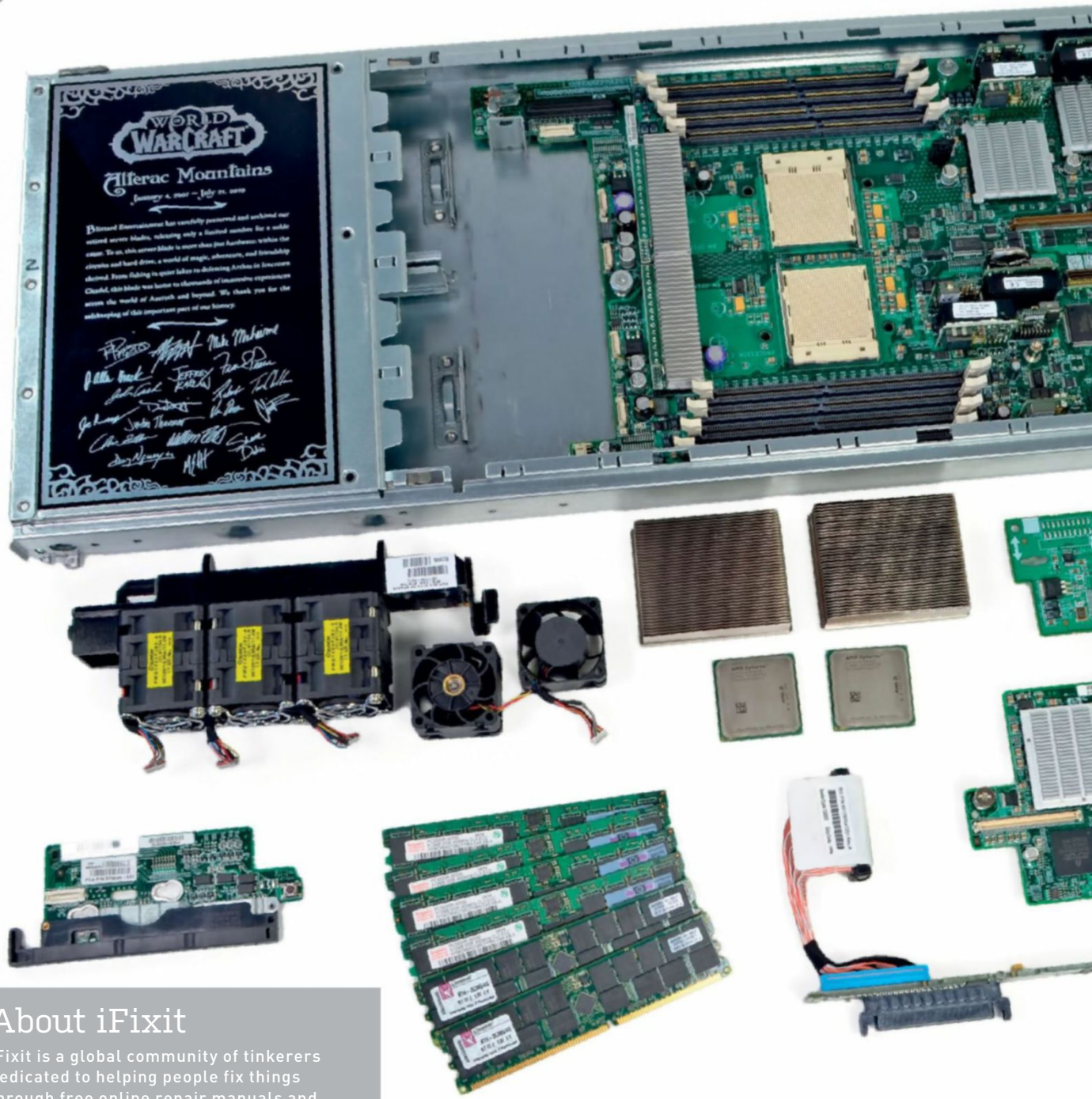
So what are the benefits of liquid-cooling? Well, all rhetoric aside, primarily it comes down to noise. Water-cooling reduces temperature—you're not likely to hit any thermal limits for processors before you hit stability issues nowadays, but keeping them below 40 degrees, even under load, ensures you can keep your fans spinning at a low speed. Sub-1,000rpm is the dream. And with that comes whisper-quiet computing, longer life for your hardware, and, of course, it looks absolutely awesome.

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

IFIXIT presents:

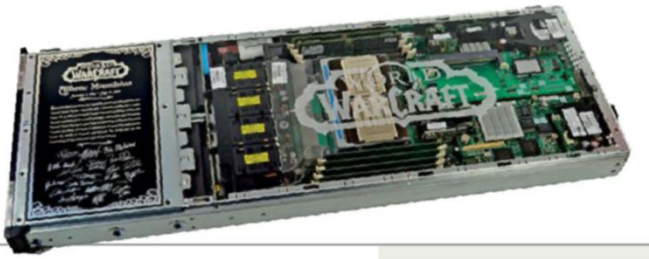
AUTOPSY

THIS MONTH WE DISSECT...



About iFixit

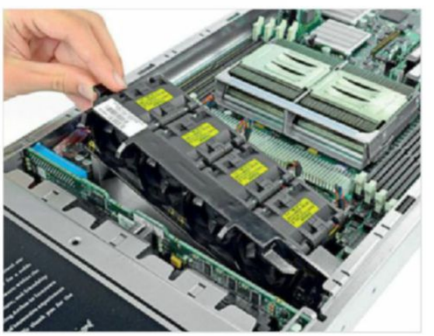
iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.



WoW Server Blade

Once upon a time, this held the chat of all the players of Alterac. Probably.

Do you even fan bro?



BACKGROUND:

Behold! We hold the *World of Warcraft* in our hands! OK, fine. Maybe just a part of it. Or a part of a part of it. And it doesn't really fit in our hands. When Blizzard decided to upgrade its servers, it sold off the old equipment as collector's pieces. Prepare to be WoWed as we take a look inside the insides of the *World of Warcraft*.

MAJOR TECH SPECS:

- 2x dual-core AMD Opteron 275 processors @ 2.2GHz
- 6GB (2x 2GB & 4x 512MB) HP DDR-ECC RAM @ 400MHz CL3
- HP Smart Array 6i SCSI controller card
- Broadcom BCM5704CKFB Ethernet CTLR single chip 10/100/1,000 300-pin HBGA
- Rage XL 215R3LASB41 graphics
- Compaq 170095-002
- Pulse H5007 1000BASE-T magnetic modules
- NetPHY AM79C874VC low power 10/100-tx/fx Ethernet transceiver

KEY FINDINGS:

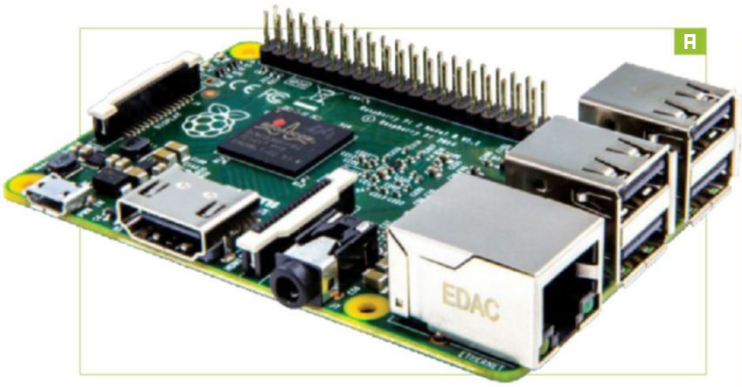
- This particular server blade is an HP ProLiant BL25p that Blizzard decked out with a commemorative plate. It's one of several server blades sustaining the Alterac Mountains from January 4, 2007 until July 21, 2010.
- The transparent panel covering all the mechanical madness inside provides shoddy protection, but is nonetheless ornate. -10% armor. +15% intellect.
- Twisting a few knobs is all that's required to remove the SCSI controller, responsible for interfacing with hard drives, scanners, tape drives, and other alliance technologies.
- The DC power filter has an input of -43 V ~ 57 V at 13 A max. That's 546 watts of maximum power! As this is just a power filter, not a transformer, the output is almost the same: -43 V ~ -57 V at a maximum 12.4 A. Once the server juice has been filtered, it is converted to the correct voltage by the power converter—two identical modules on top of each other, using the standoffs between them as a power relay. The output is 12 V, 40 A, for a whopping 480 watts.
- The *WoW* server blade has two dedicated hard drive bays: "A device or blank must occupy all bays during operation."
- A T15 Torx screwdriver is strong enough to slay any beast, including that which stands in the way of removing this mobo.
- Repairability Score: 10 out of 10. No security screws; modular, easy-to-access components. HP provides online maintenance repair documentation. It should be noted that these server blades are designed to be easily maintained and eventually disposed of. We appreciate HP being so mindful of the repair and maintenance aspect of its products.

Create 3D Graphics with Python & Pi3D

YOU'LL NEED THIS

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

DESPITE ITS ITSY-BITSY FORM FACTOR, and notwithstanding its fairly low CPU power, the Raspberry Pi [**Image A**] is blessed with some workman-like graphics hardware. Specifically, the Broadcom VideoCore IV is a dual-core affair, supporting OpenGL ES 2.0 and hardware decoding of 1080p 30fps h.264 video. All well and good, but what is OpenGL ES, and how can we use it to make pretty graphics? Good questions, and it just so happens that this article is devoted to their answers. OpenGL has bindings available for many languages, but using these directly is not for the faint of heart—programming in OpenGL is not really anything like programming in Python. Fortunately for the Pythonistas, there are a few options that enable you to avail yourself of all the 3D goodness without having to conformally map your brain around so many alien concepts. For example, there is Intel's Clutter, using Cogl as a backend, as we shall explain.... –**JONNI BIDWELL**



1 CLEAR THE CLUTTER

Clutter is still a popular way to do things—surfaces are abstracted to Stages, and things that move about on a Stage become Actors. Clutter can even work without an X server, which is great for lightweight demos. It does, however, need to be patched and recompiled in order to use OpenGL ES, which you can read about on the Raspberry Pi website (http://bit.ly/ClutterandCoglonPi).

» You'll be pleased to learn, however, that there's an even easier way to harness the Pi's 3D power, thanks to the sterling work of Tim Skillman, Paddy Gaunt, and Tom Ritchford.

» Back in 2011, Skillman posted some experimental code to the Raspberry Pi forums and, met with encouragement and enthusiasm, before long, the project blossomed. You can read the official release here: www.raspberrypi.org/pi3d. But by now you're probably itching to get started, so follow the instructions (see "Installing Pi3D," opposite), and you'll be all set.

2 DESTINATION: EARTH

Pi3D is best learned by example, so let's start with the "Earth.py" file in the "demos" directory of the "DVD" folder you can download from http://bit.ly/1US48iB. This will teach us all about spheres, textures, keyboard input, and a little celestial geometry.

» Since the world is, or ought to be, transitioning to Python 3, we begin with some forward compatibility, courtesy of the "__future__" module. Then we import some trig functions, since you can't get far without sin and cos, and the "pi3d" module itself. The fun begins with the setup of the all-important "DISPLAY" object. Because most objects rely on the existence of such an object, most Pi3D projects feature this line quite early on. The object maintains timing information, which is useful for animations. You can pass screen dimensions to the "create()" function—we use a small 50x50 window, which we set up with a black, opaque background:

```
DISPLAY = pi3d.Display.create(x=50, y=50)
DISPLAY.set_background(0,0,0,1) # r,g,b,alpha
```

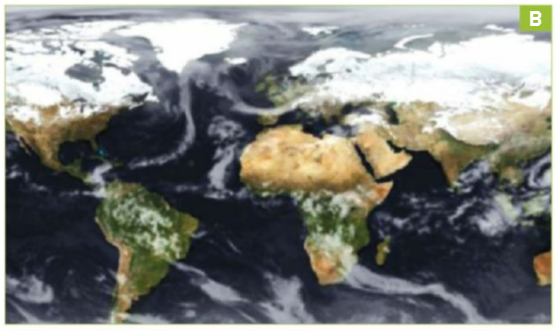
3 SHADY BUSINESS

Part of the magic of OpenGL (and OpenGL ES) is shaders. Shaders are programs written in, surprise, a shader language—in our case, GLSL—which handle the reflections, shadows, and other interactions between light and surfaces, volumes and points. GLSL follows a C-like syntax, and is designed to take advantage of the huge number of shader units on modern graphics hardware. As such, the general idea is to have many small shader programs running in parallel, to collectively produce complicated and pleasing results.

» Pi3D wisely keeps the gruesome details of its shader implementation locked up behind the scenes. But that doesn't stop us from getting some nice effects for our Earth, moon, and stars:

```
shader = pi3d.Shader("uv_light")
shinesh = pi3d.Shader("uv_reflect")
flatsh = pi3d.Shader("uv_flat")
```

» The "uv_light" shader uses light directions and shadows to create a 3D effect, unlike "uv_flat," which just renders the texture with no color transformation. The "uv_reflect" shader reflects one image in another one. We shall use it to reflect the bump map image in the moons'



surfaces; in the smaller moon, we also reflect the stars. The demos come with a whole variety of imagery in the "textures" subdirectory. The PNG files here have transparency information, which is useful as we will be interested in what's going on behind them. This is a 3D tutorial, after all. For example, we will shortly overlay the mostly transparent file "earth_clouds.png" on top of our Earth [**Image B**], to give it a vaguely ethereal atmosphere. All sunshine makes for a desert, a wise man once said. The "True" argument in the first line specifies that partial transparency is respected for our clouds. First, we load all the textures:

```
cloudimg = pi3d.Texture("textures/earth_clouds. png",True)
earthimg = pi3d.Texture("textures/world_map.jpg")
moonimg = pi3d.Texture("textures/moon.jpg")
starsimg = pi3d.Texture("textures/stars2.jpg")
watimg = pi3d.Texture("textures/water.jpg")
moonbmp = pi3d.Texture("textures/moon_nm.jpg")
```

» Textures aren't really of any worth without some sort of surface on to which they can be mapped. We're going to draw the Earth and the moon, which we will represent with spheres. We'll define two spheres for the Earth: one showing the surface details, and one (with a slightly larger radius) for rendering the atmosphere and other shader effects.

4 OVER THE MOON

We will also have two moons, giving a hierarchical system of rotations, in which a smaller moon orbits a larger one, which in turn orbits the Earth. We also specify a plane on which to draw the background starfield. Besides specifying the requisite radii and centers, the Sphere construct also takes two extra parameters—slices and sides—which decree the number of latitude and segments by which the sphere is approximated. It's true, even in this day and age, we haven't evolved beyond pixels and straight lines, so we can't draw an actual sphere. We can, however, get a nice, easy way to work with simple keyboard input, which we will use later on for the sole purpose of ending

INSTALLING PI3D

Pi3D has a few dependencies, including some headers, which you'll find in the Raspbian repositories. So, first update and upgrade, then install the required packages:

```
$ sudo apt-get update
$ sudo apt-get upgrade
$ sudo apt-get install python-dev
python-setuptools libjpeg-dev zlib1g-
dev libpng12-dev libfreetype6-dev
```

Pi3D and the Pillow Python library on which it depends aren't in the Raspbian repositories at the present time, but fear not: they exist in the Pip repositories, so you'll want to install Pip, and use it to grab 'em:

```
$ sudo apt-get install pip
$ sudo pip install Pillow
$ sudo pip install pi3d
```

By default, the 512MB Pi models, B and B+, allocate 64MB to the GPU. While many of the Pi3D demos will work fine with these rations, some require a little more. You can change the GPU memory allocation, among other system settings, with the "raspi-config" utility.

```
$ sudo raspi-config
```

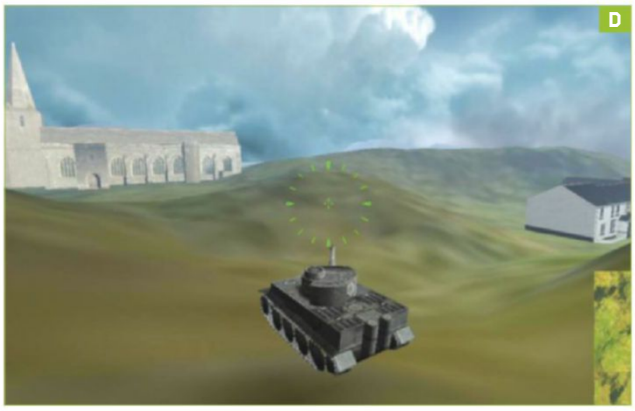
Using 128MB will suffice, and should still enable you to run a few desktop applications. The Pi3D demos can be cloned from GitHub:

```
$ cd ~
$ git clone git://github.com/pi3d/pi3d_
demos
```

This will create a directory "~/pi3d_demos," from which you can, for example, explore Buckfast Abbey [**Images C and D**]:

```
$ cd ~/pi3d_demos
$ python BuckfastAbbey.py
```

Unfortunately, the Abbey shop, stocking the famously fortified tonic wine, is missing.



the program:

```
mysphere = pi3d.Sphere(radius=2, slices=24, sides=24,
name="earth", z=5.8)
mysphere2 = pi3d.Sphere(radius=2.05, slices=24, sides=24,
name="clouds", z=5.8)
mymoon = pi3d.Sphere(radius=0.4, slices=16, sides=16,
name="moon")
mymoon2 = pi3d.Sphere(radius=0.15, slices=16, sides=16,
name="moon2")
myplane = pi3d.Plane(w=50, h=50, name="stars", z=30)
mykeys = pi3d.Keyboard()
```

» If you don't specify x, y, or z co-ordinates for your sphere, it is placed at the origin.

5 INTO ORBIT

We describe the orbit of the moon around the Earth and that of the secondary moon around the moon [**Image E**] with the parameters "rot1" and "rot2" respectively. These will be incremented as the main loop (which we're getting to) progresses. The radius of each orbit is given by "m1Rad" and "m2Rad." Initializing these to 90 and 0 degrees respectively means that (from our point of view) the big moon is in front of the Earth, and the little moon is horizontally adjacent to the big moon.

```
rot1=90.0
rot2=0.0
m1Rad = 4
m2Rad = 0.6
```

» As well as rotating around other bodies, we also rotate the Earth and the two moons about their own y axis. The y axis is the one that corresponds to the vertical direction on your screen, just like in *Minecraft*, so rotating about this axis is like skewering the Earth pole to pole and then spinning it, only less destructive. We rotate the clouds sphere at a rate slightly faster than that of the Earth, which makes for a nice effect, and is vaguely more accurate because the clouds aren't stuck to the Earth. And seeing as everything else is spinning, we also rotate the background starfield—because this is only two-dimensional, the only sane axis to rotate about is the z axis.

ANOTHER PI TUTORIAL NEXT MONTH

6 CELESTIAL BALLET

We redraw the "moon" and "moon2" spheres by changing their position properties, using high-school trigonometry to come up with new co-ordinates. The "DISPLAY" object we set up gives us a main event loop, so we use this to govern our celestial ballet:

```
while DISPLAY.loop_running():
  myplane.rotateIncZ(0.01)
  mysphere.rotateIncY(-0.1)
  mysphere2.rotateIncY(-0.14)
  mymoon.position(mysphere.x() + m1Rad*sin(rot1),
mysphere.y(), mysphere.z() - m1Rad*cos(rot1))
  mymoon.rotateIncY(-0.1)
  mymoon2.position(mymoon.x() - m2Rad*sin(rot2),
mymoon.y(), mymoon.z() + m2Rad*cos(rot2))
  mymoon2.rotateIncZ(-0.61)
```

» Now we use the shaders to add textures and effects to our heavenly bodies. The reflect shader used on the moons takes a couple of numbers after the textures, which specify the number of tiles to use and the strength of the reflection respectively. The clouds have to be drawn last, otherwise the transparency blending will not work: You're not allowed to subsequently add objects further away and obscured by the semi-transparent one when "blend = True" is specified, so it's safest to add such textures last of all.

```
  mysphere.draw(shader, [earthimg])
  mymoon.draw(shinesh, [moonimg, moonbmp], 6.0, 0.0)
  mymoon2.draw(shinesh, [watimg, moonbmp,
starsimg], 3.0, 0.8)
  myplane.draw(flatsh,[starsimg])
  mysphere2.draw(shader, [cloudimg])
```

» Now we increment the rotation parameters—the smaller moon orbits the larger one about four times as fast as the larger moon orbits the sun:

```
  rot1 += 0.005
```

WHAT IS OPENGL?

You've no doubt heard of OpenGL, the unified API for talking to graphics hardware. The language originated back in 1992 at Silicon Graphics, who decided that open-sourcing a standard would be a good way to weaken its competition. It worked well, but then Microsoft's Direct3D came along. But no matter—OpenGL will not be obliterated, and one of the reasons for this is OpenGL ES. This is the subset of OpenGL used on mobile devices, embedded systems, and some games consoles. Unlike familiar desktop graphics cards, these machines often lack oodles of registers and on-chip floating point support, so things must be reworked accordingly. But the principle remains the same: to have a uniform method for efficiently offloading textures, light, and perspective calculations to the graphics hardware.

Like OpenGL, OpenGL ES is developed royalty and license-free by the Khronos Group, a consortium of industry giants and academic institutions. Besides OpenGL, Khronos also co-ordinates development of OpenCL, WebGL, EGL, and a few other video-themed standards.

In August 2014, the Khronos group welcomed Microsoft as a member, but it would be paranoid to assert that this is a Redmondian attempt to take down OpenGL from the inside. The fact of the matter is that it's in everyone's interests to have an open standard for mobile graphics, and it's in everyone's interests for these standards to have input and support from all the major players. The old MS strategy of embrace, extend, extinguish will not work, as it is entirely incongruous with the views of other contributors, such as AMD and Nvidia.


```
rot2 += 0.021
```

» Since we went to the trouble of setting up a "Keyboard" object earlier, it would be a shame not to use it. We'll catch two keyboard events—pressing Esc (key index 27) will end the program, and pressing p (key index 112) will take a screenshot.

```
k = mykeys.read()
if k >-1:
  if k==112:
    pi3d.screenshot("earth1.jpg")
  elif k==27:
    mykeys.close()
    DISPLAY.stop()
    break
```

7 BLURRED LINES/SPHERES

So, that covers the supplied Earth demo—feel free to mess with it in whatever manner you see fit. Alternatively, stick with us and follow our meddling. We shall start with some depth-of-field blurring of the moon, so that it goes out of focus both when it gets close to us, and when it is far away.

» To work this magic, we start by invoking the "Defocus" module. Place the following line somewhere before the main loop; after the lines specifying the shaders is as good a place as any:

```
defocus = pi3d.Defocus()
```

» Defocusing works by enclosing the standard object "draw()" calls inside a block delimited by "start_blur()" and "end_blur()." The objects "drawn" inside this block are rendered into a buffer and won't appear on the screen. To make them visible, use the "blur()" method, which will render them with the appropriate distance blur. So wrap the line beginning "mymoon.draw" as follows:

```
defocus.start_blur()
mymoon.draw(shinesh, [moonimg, moonbmp], 6.0, 0.0)
defocus.end_blur()
```

» The blur method, which does the actual drawing, takes three additional arguments (besides the name of the Shape object to draw): the focal distance, the distance beyond (or nearer than) which everything will be maximally blurred, and the degree of maximum blurring. We'll set the zero-plane to be z=0, and since our moon's orbit has a radius of 4 units, we'll set the second parameter to 3. Setting the maximum blur too high will cause banding, but experimentally 5 seems to be a reasonable setting here. Enact all this with the following line:

```
defocus.blur(mymoon, 0, 3, 5)
```

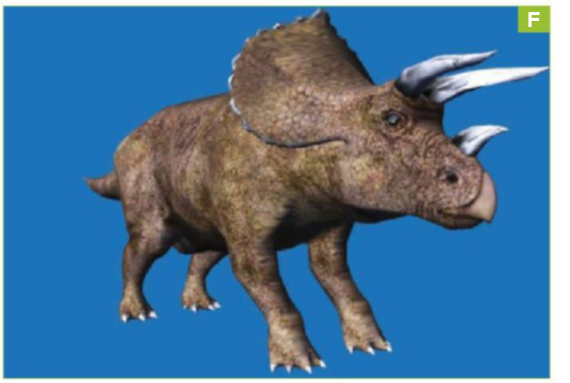
8 MAN WITH A MOVIE CAMERA

But the fun doesn't stop there; by adding a Camera object, we can immerse ourselves completely in our three-body system. Using only a tiny bit of trigonometry, and our implemented "Keys" object, we can move our celestial observer and change our viewpoint. We'll need to add the radians function to the trigonometry functions, which we have already imported from the math module. Set up a "Camera" object, and initialize some properties for it after the "DISPLAY" declarations:

```
CAMERA = pi3d.Camera()
rot = 0
tilt = 0
rottilt = True
camRad =5
```

» We'll use the "rottilt" boolean to trigger any changes to the camera position or orientation. Rotating or tilting the camera is simple, but changing its radius (determined by "camRad") requires some spherical trigonometry ugliness. So, the beginning of the main loop becomes:

```
while DISPLAY.loop_running():
  if rottilt:
    CAMERA.reset()
    CAMERA.rotate(tilt, -rot, 0)
    CAMERA.position(camRad * sin(radians(rot) *
cos(radians(tilt)), camRad * sin(radians(tilt)), -camRad *
cos(radians(rot)) * cos(radians(tilt)))
    rottilt = False
```



9 GROUND CONTROL

We need to set up the keys to control the Earthcam—we'll use standard W, A ,S, and D for the rotations, and +/- to zoom in and out. So, change the beginning of the key-handling block to the following:

```
if k -> -1:
  rottilt = True
  if k == 112:
    pi3d.screenshot("earth1.jpg")
  elif k == 119:
    tilt += 2.0
  elif k == 115:
    tilt -= 2.0
  elif k == 97:
    rot -=2
  elif k == 100:
    rot +=2
  elif k == 61:
    camRad -= 0.5
  elif k == 45:
    camRad += 0.5
```

» Now you've got action and camera, why not look into adding some lights as well? Some kind of distant sun, perhaps. You'll find the documentation at http://bit.ly/Pi3DDocs, but the supplied demos do a great job of introducing all of the available constructs, and you can easily import 3D models [Image F] in the Panda3D .egg archive file format.

Blend Images to Create Star Trails

YOU'LL NEED THIS

ADOBE PHOTOSHOP
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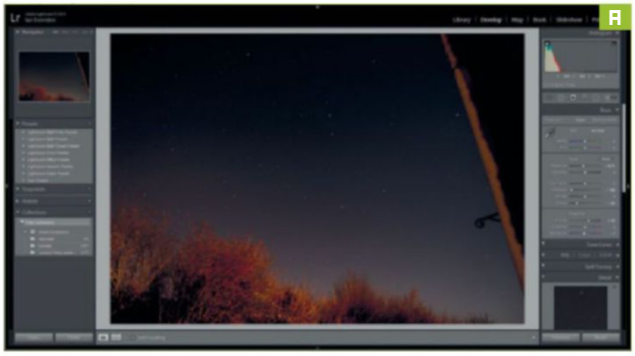
DIGITAL CAMERA
With a long exposure facility, and clear skies.

AS THE EARTH SPINS, the stars appear to move. They take a graceful arc across the night sky, rising and setting much like the sun and moon. If you want to capture this motion, you need a camera that can keep its shutter open for long exposures—15 or 30 seconds—without an undue amount of noise. You also need a reasonably "fast"—or wide aperture—wide-angle lens. It's the length of exposure that captures the movement of the stars, but a wider aperture lens lets in more light, for a stronger effect, and the ability to use a lower ISO sensitivity setting to reduce electronic noise. The lens needs to be wide-angle because the sky is big, and we want to capture as much of it as possible.

Set your camera up on a tripod on a clear night, facing due north (or south, if in the southern hemisphere), and aimed roughly at the celestial pole—many smartphone apps can find this for you. Take about an hour's worth of 30-second exposures, and import them into Photoshop. **–IAN EVENDEN**



1 GET THE SHOTS

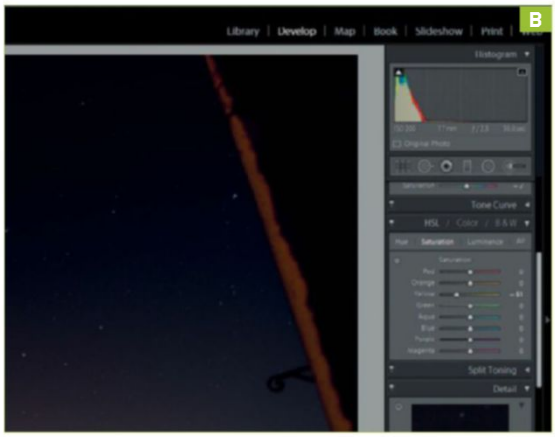
Getting that hour's worth of data can be tricky. If you're using a DSLR, set it for 30-second exposures, and use a remote release—the trigger button on these can often be locked in the down position, and the camera's motor drive will ensure you get a shot every 30 seconds. If you're trying to do it with a cell phone or compact camera, you're in for a slightly more boring time of it, as you manually press the button 120 times. There are apps on various app stores that can help you, if using a smartphone, and for a compact camera, a bit of duct tape can work wonders. An hour is about the minimum we recommend for getting this effect. If you're patient enough to take more, you'll end up with longer star streaks. Take a few test shots beforehand, so you can zero in on ISO and aperture settings. We used ISO 200 and f/2.8.

2 DEVELOP

If you've chosen to shoot raw images or JPEGs, you need to make sure all the files are treated the same. Import them into Lightroom, and edit one photo so it looks the way you want [**Image A**]. Unless you happen to live in a tent in one of the national parks, the chances are you'll get some light pollution from street lighting. This yellow glow can make its way on to any pictures you take of the night sky, and can be difficult to remove, although its effect can be lessened.

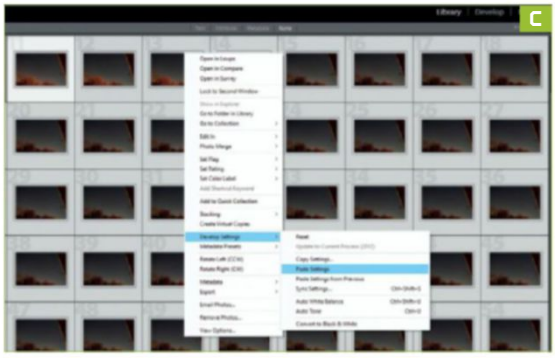
3 DESATURATE

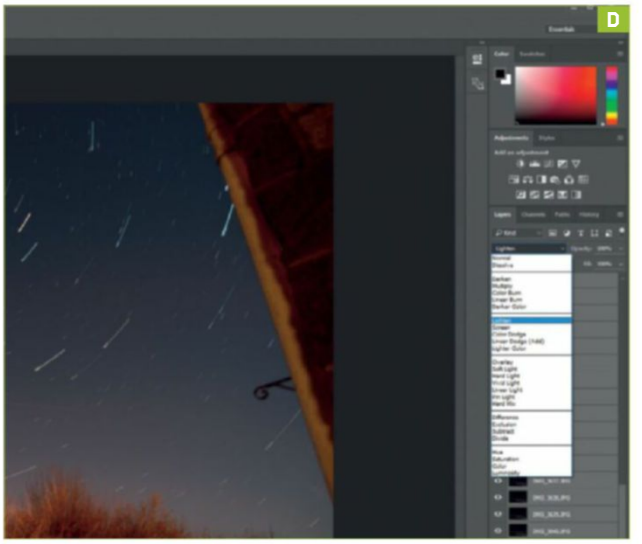
As the glow of light pollution is often yellow (though blue is another color that can appear), sliding down the yellow saturation control in Lightroom's Develop module is a good way to remove it [**Image B**]. Unfortunately, this also removes the color of any yellow stars you captured as well. If it's affecting your stars too much, we'll show you another way at the end of this tutorial.



4 COPY AND PASTE

Once you've got an image looking the way you want it to, go to the Library module, right-click the image and copy the Develop Settings, then select the rest of the images and paste the settings [**Image C**]. All the images should now have a uniform look, but with the stars in different positions. If you open an image, then hold down the right arrow key, you can watch the sky revolve in a kind of stop-motion animation.





5 EXPORT

If you exported these images and opened them in Photoshop, they would open as a series of individual files. We want them in the same document but on different layers, so keep the images selected, head to Lightroom's "Photo" menu, and choose "Edit In → Open as Layers in Photoshop..." Depending on the size of the files, and the speed of your CPU, you might be in for a little wait.

6 BLEND

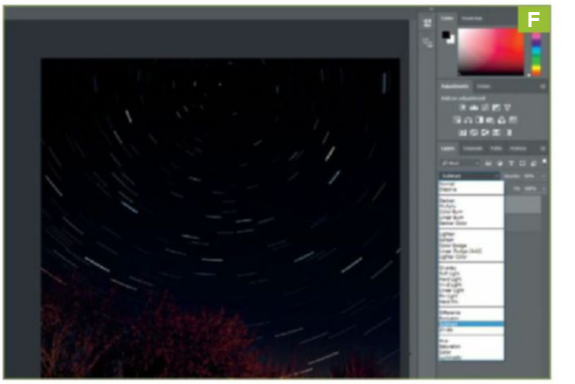
Select every layer in the "Layers" palette, and choose the "Lighten" blend mode [**Image D**]. In an instant, your star trail image should become visible. "Lighten" discards dark pixels, while leaving light ones unchanged, turning what was a series of light dots across multiple images into streaks. The length of the streaks is directly linked to the amount of time you left your camera to take exposures—more time gets you longer streaks and a better effect.

7 FINISHING TOUCHES

Crop your image—we had a bit of house in ours that we don't want—and flatten the layers [**Image E**]. Save a PSD version before flattening if you want to come back and re-edit it later.

8 ELIMINATE LIGHT POLLUTION

To remove troublesome light pollution without affecting the star trails, duplicate your flattened layer, and place the duplicate on top in the "Layers" palette. With this layer selected, head to the "Filter" menu and choose "Gaussian Blur." Apply this filter strongly—use a "Radius" setting of 50 pixels or so—so nothing can be seen of the image. Set the blend mode for this layer to "Subtract" [**Image F**], and the star streaks should reappear while the light pollution vanishes. Back off the "Opacity" slider for a subtler effect—50% say. "Subtract" subtracts pixel values in one layer from the other, and shows black if it returns a negative number. Luckily, the night sky is black, so we get a natural-looking result. You can try blend modes from the fourth group on the drop-down as well if you want to experiment; "Soft Light "or "Pin Light" can look good.



KEEP EXPERIMENTING

Once you've got the stars to blend like this, it's a technique that can be applied to anything else that moves and has a light. Try it on long exposures of cars moving under a highway bridge at night, or maybe even fireflies, if you're lucky enough to get them where you live. Fire poi practitioners are often happy to perform for the camera, their flames taking on an almost liquid form in the final image. Dumb luck is an important part of all photography—it's an art rather than a science, despite its origins in chemistry and physics. Try digital editing techniques on new subjects, and you never know what's going to come out the other side.

Control the Airflow Within Your Chassis

YOU'LL NEED THIS

A CASE AND FANS
All respectable cases have support for fan mounts internally.

INTERNAL AIRFLOW; let's cut the crap—it's one of the biggest dividers of opinion there is, second only to cake or pie. So, why is it so complex? What's a positive or negative pressure system? Static pressure? CFM? What's that? Well, that's what we're here to answer. Whether your woes lie with choosing which fans to use to cool your mighty AIO, or with the age-old argument between static pressure and high airflow fans, don't you worry—we've got your back!

Is internal airflow really that important? In a lot of ways, it's more vital than people realize; the more air you circulate, the better temperatures you'll have internally, and the more comfortable your overclocks will remain in turn. Also, you can wow everyone with your in-depth knowledge of fans. Come on—who doesn't love fan tips? –ZAK STOREY

1 FAN ORIENTATION

The first thing you need to identify when it comes to your fans is which way pulls air in, and which pushes it out. Most commonly, the side with the blades exposed is the intake, and the side with the guards will exhaust air around or out of your chassis.

2 STATIC PRESSURE VERSUS AIRFLOW

Identifying a static pressure optimized fan as opposed to an airflow fan is crucial. An easy way to tell them apart is the design and orientation of the fan blades. Fat and wide [**Image A**]? You're looking at a static pressure fan. Skinny and sleek? That's airflow optimized. Static pressure is designed to force air through dense or resistive areas, while airflow fans push larger quantities of air into a chassis at a lower pressure.

3 WHEN TO USE A STATIC PRESSURE FAN

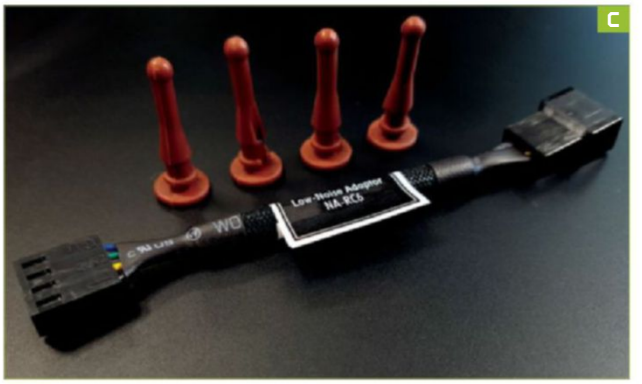
We'll no doubt divide opinion here. Static pressure fans are absolutely fantastic for radiators, AIO coolers, and CPU heatsinks. Usually, those pesky air towers and radiators have a compact enough arrangement that a static pressure fan can easily take advantage of the higher pressure. However, this isn't always the case. For radiators, in particular, it can depend on the density of the fins within it, also known as FPI (fins per inch). In short, the higher the density, the higher the static pressure you'll need to push cool air through it. Take EKWB's XE 240mm radiator. It's a thick old girl—coming in at just under 2.4 inches in depth, it features an FPI of just 16 [**Image B**]. However, if you take the PE variant, coming in at a meager 1.5 inches, you'll notice it has an FPI of 38. In this scenario, you would be far better off using a static pressure fan. However, the first radiator really wouldn't see any gains from using one, because the density is just too low.

4 WHEN TO USE AN AIRFLOW FAN

This is a little easier to answer now we've clarified the radiator conundrum. In short, if you've got absolutely no resistance, unless you're trying to thematically match a build with all the same fans, you should always choose an airflow optimized fan. It's not as difficult as it sounds—most companies offer both static pressure optimized and a standard airflow variant of the same fan design; Corsair's AF120 and SP120 series, for example. Of course, if your radiator has less than 18 FPI, you'll actually save yourself a few bucks by grabbing that airflow fan instead of the SP variant, because you won't see any performance benefits with an SP fan.

5 WHAT'S ALL THIS ABOUT RPM?

RPM, or revolutions per minute, applies here exactly as it would in a combustion engine. The higher the revolutions, the higher the performance, but that comes at a price. Noctua's NF-F12 IPPC fans are a good example. They come in two variants (three if you include the IP67 version): a 3,000rpm version, and a 2,000rpm version. Now, the 3,000 variant pushes 109.8 CFM (cubic feet per minute)



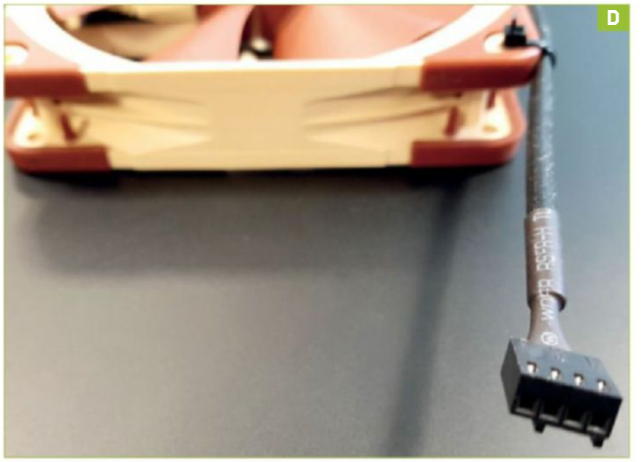
for airflow, and has a phenomenal static pressure of 7.63mm H_2O. However, at full whack, you also get a very noisy 43.5dB(A), which is bad. Compare that with the 2,000rpm variant, and you're down to 71.7 CFM on airflow, and a static pressure rating of 3.94mm H_2O. The advantage? You'll be greeted by 29.7dB(A) instead, which is around the same as a stock Corsair fan found in the H100i.

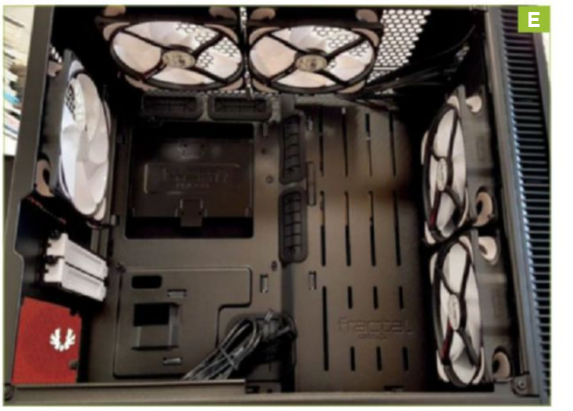
6 HOW CAN YOU REDUCE NOISE LEVELS?

Short of buying slower fans (1,500rpm or below), you can use low-noise adapters to reduce the voltage powering the fan, or use PWM variants instead, so you can control the fan speeds with pinprick precision through fan control software on your desktop. You could also install fans with rubber grommets [Image C], as opposed to the traditional fan screw. Outside of fans, you could opt for a noise-optimized case—one that uses sound-dampening material, such as Fractal's Define R5. Although the side panels will inherently be heavier, due to the noise-dampening fabric attached to the interior panels, it will deaden any excessive vibrations dramatically. Failing that, you could opt to use a fan controller, such as Phantek's PWM fan hub. These work similarly to a low-noise adapter, and most enable you to plug both PWM and 3-pin fan headers directly into them, which are then controlled by a single header, or software on the motherboard itself.

7 WHAT DO ALL THOSE NUMBERS MEAN?

To get a good idea of what these figures represent, your best bet is to compare several different fans on your favorite etailer's website. But for a quick roundup, static pressure is often measured in mm H_2O (2.2 is the average), higher equals better. Airflow is measured in CFM (70–80 is the average), higher is still better. Noise levels are measured in dB(A), 16 being super-quiet, 30 being your average CPU cooler fan at full load, 40 being a localized





earthquake within your chassis (OK, we jest here, but you get the point).

8 PULSE WIDTH MODULATION (PWM)

PWM fans account for about 30 percent of the total fans out there today. In short, instead of utilizing 12V, 7V, or 5V to power the fans, the additional pin [Image D] allows the motherboard to fluctuate the amount of voltage powering the fan. This way, it can control the fan's speed with incredible accuracy.

9 WHAT'S NEGATIVE AND POSITIVE PRESSURE?

These phrases refer to how you have your case set up. It sounds ridiculous, but once you introduce fans to a system, you actually create a pressure system inside the closed chassis. There are three different types of pressure system: a balanced system, where there's just as much air going in as going out (two intakes, two exhausts); a negative pressure system, where more air is being exhausted than is being brought into the chassis (one intake, three exhausts); and a positive pressure system, where more air is being brought into the chassis than exhausted (three intakes, one exhaust). In reality, they are all equally effective at cooling, and you'll only find very minor differences between the three. After all, exhausting hot air out of your chassis helps keep your motherboard on ice and your overclocks steady, and replacing that hot air with cold air through an intake helps as well. Ultimately, it's all about air circulation, far more than whether you run a positive, negative, or balanced system.

10 BALANCE IS KEY, THEN?

Well, no—it's actually more about dust than anything else. In today's world, cases are littered with dust filters: intakes designed to reduce the amount of dust entering your system. After all, dust is the biggest hardware killer of them all, and for an aesthetic build, it looks awful as well. But even with all of those filters, you're still going to have holes and areas that aren't filtered (rear exhaust slots, PCIe slots, and other gaps in the case's construction). In a negative system, thanks to thermodynamics, cool air is pulled in through all of these unfiltered areas, in turn bringing dust into the system. However, in a positive system [Image E], air is actually exhausted or pushed out of these gaps and unfiltered areas, pushing the dust out of your case as well. It's not going to keep the dust out indefinitely, but it'll certainly help, and it means your system will require a lot less maintenance overall.

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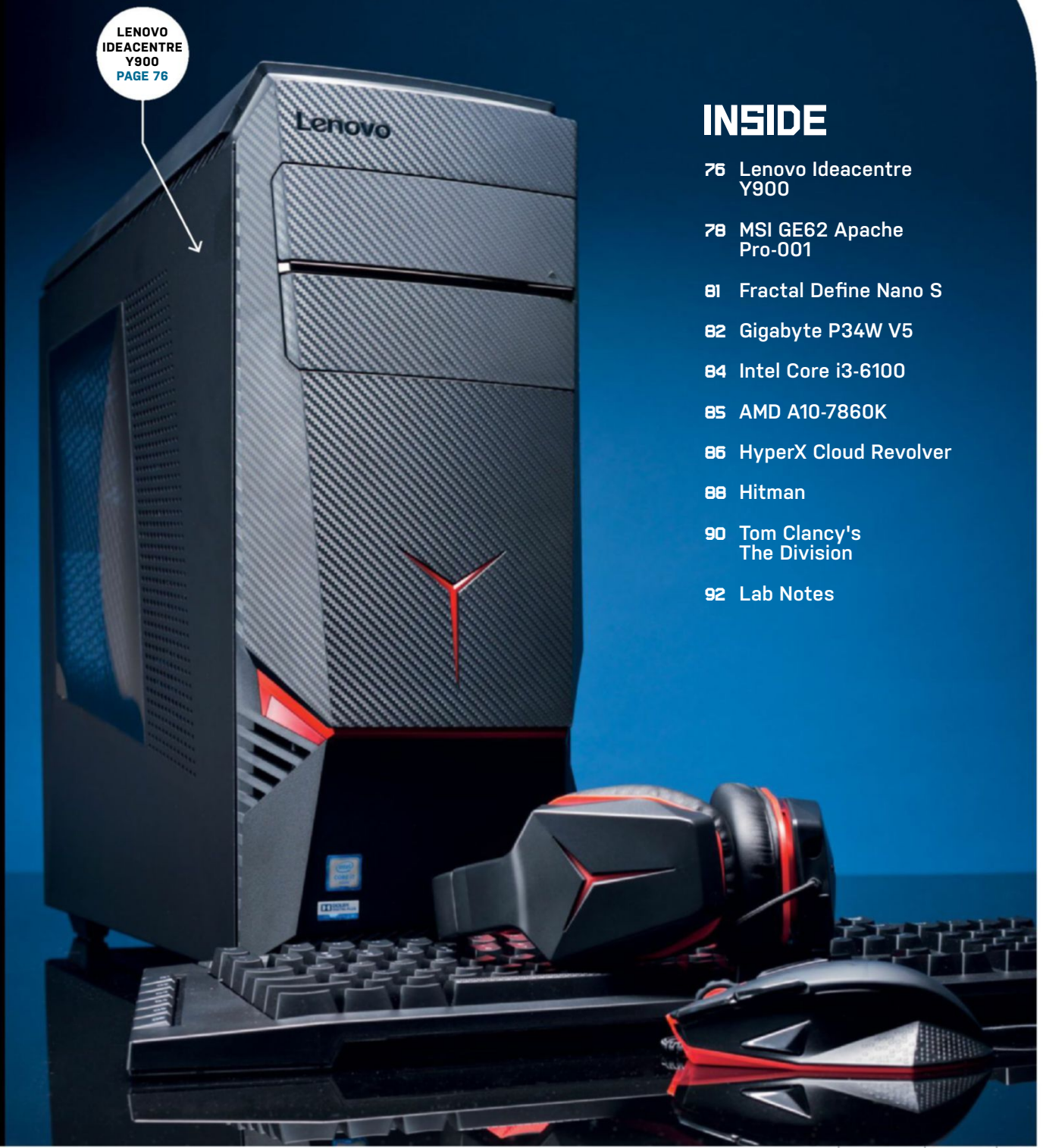


INSIDE

The Ideacentre Y900 features an aggressive design without looking too gaudy.

Lenovo Ideacentre Y900

Well, it's an OK idea...

LENOVO MAY BE the largest PC seller in the world, but it isn't a household name as far as PC gaming is concerned. The Chinese company wants to change that, especially as it pertains to the desktop space. Enter the Ideacentre Y900. The mid-tier desktop line features an edgy and aggressive design, but doesn't look too gaudy. A good Ideacentre or just a bad idea? Read on....

The Ideacentre Y900 uses a mid-tower chassis, and has some sharp edges, fancy red lighting, and a carbon fiber aesthetic, which gives the package some pizazz. The side doors open up unconventionally, and took us a second to figure out. Not only is there a latch on the back that you have to release, but there's an unlock button on top for the side doors. Once you open up the case, you'll notice that the guts include an Intel Core i7-6700K CPU, 8GB RAM, and a GeForce GTX 970. While we would have preferred 16GB RAM, there are two empty DIMM slots if you want to add more. The specs also make this VR-ready.

For storage, the Y900 comes with a 2TB hybrid HDD coupled with a 120GB SSD. The SSD is a bit small for our liking, as we recommend at least 250GB for the OS drive, but there is room for four storage drives in total. For cooling, the Y900 uses an interesting red glowing air-cooler that we've never seen before, coupled with a glowing red 12cm exhaust fan at the rear of the case. Everything is powered via an 80-plus bronze certified 625-watt PSU.

EIGHT AGAINST FOUR

When it came time to use that firepower, the Y900 performed modestly compared to our zero-point system. To be fair, our ZP has three GTX 980s and a 5960X CPU. In single-threaded CPU tests, performance was roughly on par. When it came to the multithread-heavy x264 test, however, it performed 43 percent slower. Ouch! But we are comparing an octa-core CPU against a quad-core one. In graphics, the delta was even bigger, as you'd expect. Across the board, we saw a delta of 56-68 percent. This means you'll be able to max-out almost everything at 1080p, and even some games at 1440p, but it's far from a 4K rig. For fun, we also ran the SteamVR benchmark, and the Y900 garnered a 6.4 fidelity score, which barely puts it in the"high" tier ("very high" is the best). This means it should be able to play most games on high in VR, but don't expect to max-out settings.

While our unit costs $1,600, which is expensive for a system with these specs, it also came with a mechanical keyboard, gaming mouse, and USB headset. The keyboard uses kailh switches and feels like red/brown ones, in that they aren't super-loud, like blue or green switches. The headset uses a USB interface, feels super-comfortable, and sounds competent. It also glows and has a removable mic. We weren't as enamored with the mouse, however, which is a little too bulky for our taste.

While the Y900 isn't a bad starter kit for the aspiring PC gamer, and does come with decent peripherals, there is a small price premium, especially if you have your own gaming gear. This isn't a great Ideacentre, but you could do worse. **–JIMMY THANG**

VERDICT 7

Lenovo Ideacentre Y900

GOOD IDEA Comes with peripherals; VR-capable; edgy but not gaudy.

BAD IDEA Small SSD; a little overpriced; not liquid-cooled.

$1,600, www.lenovo.com

SPECIFICATIONS

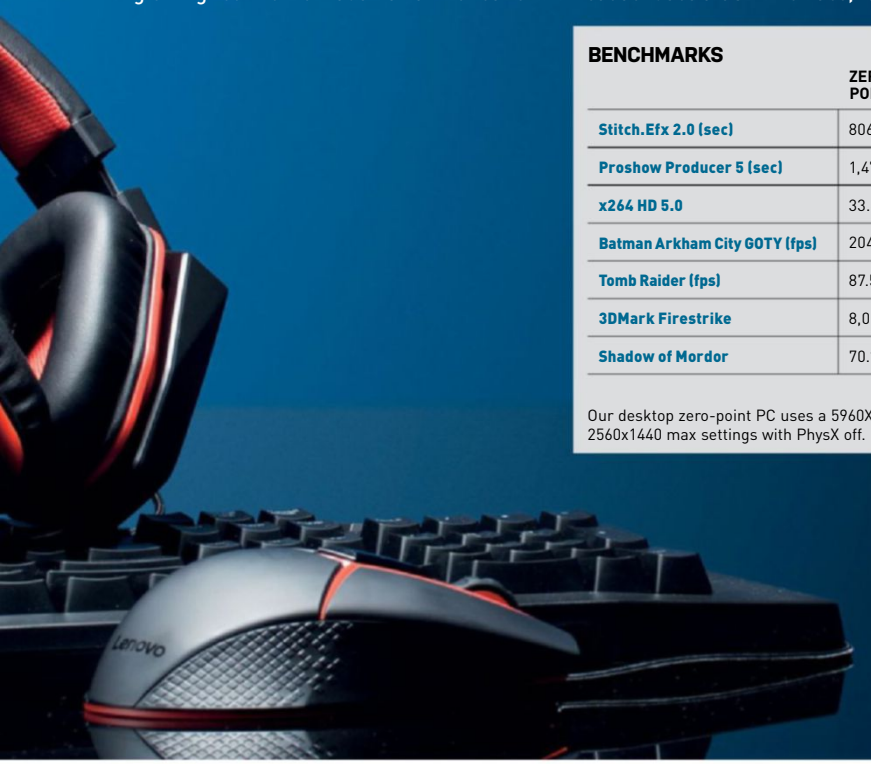
Processor	4GHz Intel Core i7-6770K
Mobo	Lenovo Skybay
RAM	8GB DDR4
Graphics	GeForce GTX 970
Storage	120GB SSD/2TB HDD
Optical	DVD burner
Case/PSU	Lenovo Ideacentre Y900

BENCHMARKS

	ZERO-POINT	
Stitch.Efx 2.0 (sec)	806	788 (2.3%)
Proshow Producer 5 (sec)	1,472	1,485 (-0.9%)
x264 HD 5.0	33.8	19.3 (-42.9%)
Batman Arkham City GOTY (fps)	204	65 (-68.1%)
Tomb Raider (fps)	87.5	38.4 (-56.1%)
3DMark Firestrike	8,016	2,500 (-68.8%)
Shadow of Mordor	70.1	27.2 (-61.2%)

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

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



MSI GE62 Apache Pro-001

The laptop equivalent of a sporty crossover SUV

It may not be ultra-thin, but it won't scorch your lap.

HAVING CHOICE can be a great thing. Much like the world of automobiles, laptops come in all shapes and sizes. Do you want a gas-guzzling truck for off-roading, an exotic sports car, a family vehicle like a minivan, or something with great gas mileage? All of these can be had, but in every case there's a trade-off being made. For laptops—and gaming laptops in particular—the biggest decisions you'll face are in the areas of graphics performance, screen size, and battery life.

MSI's GE62 aims to be an everyman gaming notebook. It's not too big to carry around, but it's still big enough that you won't end up squinting at the screen when using the native 1080p resolution. Performance is good, with a GTX 970M being a nice fit for 1080p gaming, and that in turn helps to keep the price from climbing too high. It's always fun to take the latest and greatest hotrod notebooks out for spin, but not everyone wants a muscle car.

If that sounds a little dull for your tastes, rest assured that the GE62 isn't a weak budget offering. You get a full keyboard with dedicated 10-key, multi-colored backlighting, multiple video ports, and high-speed connectivity courtesy of Killer Networking. Throw in an IPS display, and there's lots to like—there's even an M.2 PCIe x4 Gen3 slot with NVMe support. Unfortunately, the M.2 slot was occupied by a mediocre M.2 SATA drive from Toshiba. There's also no Thunderbolt 3 or G-Sync support, the latter being mutually exclusive with dynamic switchable graphics, which the GE62 supports.

Think of the GE62 as something of an affordable sports car, and you're not far from the truth. It's never going to take down a Ferrari or Hellcat, but it's got plenty of pep. Compared to our two-year-old zero-point, CPU performance has only improved around 5–15 percent, but graphics performance is a gigantic leap forward, blasting through games at roughly 2.5 times the performance of the aging GTX 765M. Unfortunately, battery life also takes a hit, ultimately falling short of three hours of video playback, though in lighter use (surfing the net, for example), you can hit five hours.

LIMITED TRUNK SPACE

Overall, the GE62 performs admirably, particularly when it comes to gaming—in our extended online test suite, it averaged 114fps at 1080p Medium, and 43fps at 1080p Ultra. With such a great foundation, the storage configuration still leaves us flummoxed. We haven't used DVDs or Blu-rays for years, but the GE62 still includes an optical drive—great if you need it; wasted space if you don't. Supporting NVMe but shipping with a 128GB SATA drive, paired with a 1TB HDD, is even more perplexing. Give us a 512GB or 1TB 2.5-inch SSD and leave the M.2 slot open for future expansion, even if it costs extra. Frankly, 128GB for an OS drive has been limiting for several years, and even 256GB is questionable. You can upgrade later, but we'd rather get a good SSD from the start. 2014 called; it wants its SSD back.

But despite a few oddities in the storage department, overall there's plenty to like. The GE62 runs as fast as everything else using the GTX 970M, and it does it in a package that weighs and costs about half as much as the extreme GTX 980 notebooks (see MSI GT72S, Holiday 2015, pg. 76). There are much faster notebooks, and there are thinner and lighter gaming notebooks as well. However, thin plus gaming often equals hot and noisy—the laws of thermodynamics are a harsh mistress—and the GE62 strikes for more of a middle ground. If you're looking for a gaming notebook that functions as a jack-of-all-trades, the GE62 Apache Pro hits most of the right notes. Just don't be surprised when the inevitable update comes along with a new GPU that uses less power and runs faster. **–JARRED WALTON**

VERDICT 9

MSI GE62 Apache Pro-001

BLAZING TRAILS Good 1080p gaming; reasonably portable; balanced system.

MIDDLE OF THE ROAD Small SSD; mediocre battery life; doesn't include NVMe SSD.

$1,449, www.msi.com

SPECIFICATIONS

CPU	Intel Core i7-6700HQ
RAM	2x 8GB DDR4-2133
GPU	GeForce GTX 970M 3GB
Display	15.6-inch, 1920x1080 Matte IPS
Storage	128GB Toshiba M.2 SATA, 1TB HGST 7200rpm HDD, BD-Combo
Connectivity	1x Mini-DP, 1x HDMI, Killer Ethernet and 802.11ac, SD reader, 2x USB 3.0, 1x USB 3.1 Type-C, 1x USB 2.0, Bluetooth 4.0
Dimensions	15.08 x 10.24 x 1.06 inches
Weight (Lap/Carry)	5.32/6.80 lb

BENCHMARKS

	ZERO-POINT	
Stitch.Efx 2.0 (sec)	962	930 (3%)
ProShow Producer 5 (sec)	1,629	1,837 (-13%)
x264 HD 5.0 2nd (fps)	13.5	15.18 (12%)
BioShock Infinite 1080p (fps)	36.1	93.3 (158%)
Metro: LL 1080p "Normal" (fps)	30.4	86 (183%)
3DMark 11 Performance	4,170	9,660 (132%)
Battery Life (1080p Video, min)	234	162 (-31%)

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 with Ultra DX11 settings; *Metro: Last Light* tested at 1920x1080 with DX11 medium quality settings, and PhysX disabled.

Fractal Define Nano S

More mini ITX madness from the Swedish chassis manufacturer

YUP: $80. That's 80. Not 140, not 100—80. How on earth has Fractal managed to build such a good-looking, feature-rich chassis for such a low price? We'll be honest—we're not sure, nor are we here to comment on Fractal's (clearly impressive) manufacturing and marketing strategy. We're here to soak up the gloriousness of this clean-cut chassis, to appreciate this case's expanded liquid-cooling support, and to fall in love with the fact that this tiny tower is available for less than it costs to spray-tan yourself orange and buy a blonde toupee.

So, where to start? Well, let's take a look at the chassis from the outside. It's not the gaudy, pointed, LED-littered affair of a gaming chassis. It's sophisticated, classy. The sharp lines synonymous with Fractal's minimalistic design style work wonders on the Define Nano. It's a box—yeah, we get that—but, at the same time, it's more than that. It's a container that will house all your expensive hardware, your pride, your joy, and sit merrily on your desk for the next two to three years.

For cooling, you're graced with a choice of up to four 140mm or 120mm fans (two in the front, two in the roof), and a final 120mm in the rear. On top of that, thanks to the Nano's particularly barren interior layout, water-cooling in this little beauty should be a dream. You can easily fit two of EKWB's PE 240mm radiators in this thing, and still have room to maneuver, thanks to all that space.

Additional features aren't exactly lacking, either. You can mount two 3.5/2.5-inch drives, there are some lovely rubber grommets (one up on NZXT's Manta), Fractal's personalized Velcro straps for cable management located in the rear of the chassis, a very swanky magnetic sliding underside dust filter, a magnetic door latch dust filter in the front, a ModuVent cover on the top, to allow for more airflow and cooling options, and, of course, sound-dampening material embedded into that rear panel as well. And last, but not least, pre-drilled holes for pump and reservoir mounting.

So, yeah, there's all that. Overall build quality is pretty sound, too. Of course, you're not going to find any crazy rigid steel and aluminum external panels, certainly not at this price point, but the plastic front is slick enough, and has the advantage of not being a fingerprint magnet, as opposed to the metal alloys of the more premium, pricier cases out there.

WINDOW SHOPPING

What is there to dislike about the Nano? Not a lot, to be honest. If you're not particularly keen on the window, you can opt for a version without—you'll also gain more sound-dampening because of it. One thing we do miss is the PSU cover, found in the likes of chassis such as the Manta, and the window does feel as though it could have been just a touch bigger, considering how empty the visible interior is of hard drives and the like. It also has slightly rounded corners, which contrast starkly against the sharp lines of the rest of the design. And lastly, similar to the Manta, it still has compatibility issues when it comes to which motherboard you use. In reality, mini-ITX boards are just a nightmare, and unlike their ATX brothers, they're simply not designed to mount vertically in a case. It's a shame—hopefully, with Kaby Lake, we'll begin to see more premium ITX motherboards, designed in a similar manner to the ATX masterpieces. But until then? You're stuck with around three different mobos to choose from.

–ZAK STOREY

VERDICT 9 KICK ASS!

Fractal Define Nano S

DEFINITIVE Fantastic value; sleek design; great cooling support; vast range of features; did we mention great value?

DERP ITX mobo compatibility; no PSU cover; window slightly rounded.

$80, www.fractal-design.com

SPECIFICATIONS

Form Factor	ITX
Dimensions (W x H x D)	8.0 x 13.5 x 16.2 inches
Cooling	Front: 2x 120/140mm Top: 2x 120/140mm Rear: 1x 120mm
CPU Cooler Clearance	6.3 inches
Graphics Card Max Length	12.4 inches
Storage Support	2x 2.5/3.5-inch
Power Supply Support	ATX

Gigabyte P34W V5

Still on the hunt for the perfect laptop

YOU WOULDN'T BELIEVE how many laptops we get offered to review. If the beginning of this year has marked anything, it's the launch of Core i7-6700HQ and GTX 970M compatible laptops. Throw that together with a PCIe SSD and an IPS 1080p panel, and you're generally on to a winner. From that point, it's just a case of finding the right price, I/O, and any other features you want.

Or is it? Well, we can scrap that bit about panel type. Gigabyte has thrown in a full 2560x1440 IPS panel, and it looks gorgeous. The extra clarity provided by those 1,612,800 additional pixels is enough to make you cry out in joy. Having the extra screen real estate here is fantastic.

PIXEL DENSITY DETAILS

"But, but, but," we hear you cry, "a GTX 970M powering a 1440p panel? That's just dumb!" And usually, we'd be inclined to agree, if it wasn't for the fact that the screen is only 14 inches across the diagonal. This means that, thanks to an incredibly powerful pixel density, you need to rely less on antialiasing than on, say, a more traditional 27-inch 1440p monitor. To clarify, the P34W V5 comes in at a classy 209 ppi; a standard 27-inch 1440p panel is almost half that, at 108 ppi. And with less of your GPU's horsepower being forced to correct for those evil jaggies, it can dedicate more of that Maxwell GPU to rendering what matters—the game.

Now that's resolved, we can look at the rest of the specification. You get 16GB of DDR4 memory, a 128GB Samsung SM951 PCIe NVMe SSD, a 1TB Seagate 2.5-inch HDD, and that Core i7-6700HQ at a stock frequency of 3.5GHz. Externally, you get a sleek black design, a typical backlit laptop keyboard, and a plethora of connectors, including three USB 3.0, one USB 3.1 Type C, a microSD slot, HDMI-out, Ethernet, Kensington lock, and, oddly, VGA. Yep, VGA, because you never know when it might come in handy, like the AMD Athlon processor and stick of 128MB DDR sitting on our editor's desk.

So, how does it perform? Exceptionally well, given its small form factor and mobile hardware. In TechARP's x264 benchmark, the P34W V5 scored a respectable 14.78fps, alongside a solid 675 in CineBench R15. CrystalDiskMark registered sequential reads of up to 2,041MB/s on the OS drive, and 40.82MB/s on 4K randoms. It did fail our temperature torture test, but that involves running Prime95 and a single instance of Furmark for five minutes. Tapping out at 95 degrees, the P34's final clock reached 2.65GHz.

In game, it paints a happier picture. At 1080p, we saw great performance in *Shadow of Mordor*, *Batman Arkham Knight*, and *Project Cars*, comfortably above 40fps. *GTA V*, *Far Cry Primal*, and *Attila* all hit 30fps, but that was at Ultra settings with the AA ramped right up. No doubt, if you tweaked that just right, you could get a far better experience than our standard benchmark runs, especially thanks to that increase in pixel density.

Any problems? Well, yes, a few. The biggest being the cooling. As we've already established, it failed our temperature torture test, throttling itself down to 2.65GHz. But to be fair, it wasn't something we expected it to pass. The biggest problem we had concerning this chilling matter was the noise; this is not a quiet laptop. Although it isn't as loud as some of Gigabyte's disguised gaming offerings—looking at you, Aorus—it's still enough to warrant a good pair of headphones in game. Other than that, after pressing the power button, it takes a good six seconds to actually respond.

All in all, the Gigabyte P34W V5 is a sound gaming laptop. It's sleek, elegant, and sexy, while packing enough of a wallop to ensure we can get the best out of that resolution and form factor. If it wasn't for that cooling noise and thermal throttling, it would definitely score a "9." **–ZAK STOREY**

VERDICT 8

Gigabyte P34W V5

+ GIGABYTE Impressive screen; almost perfect spec; sleek design; not garish; solid price.

– GIGABOOT Noisy; slow power-on.

$1,650, www.gigabyte.com

BENCHMARKS

	Gigabyte P34W V5	Cyberpower Fangbook SX-300
CineBench R15 (Index)	675	**676**
TechARP's x264 Benchmark (fps)	14.78	**14.92**
HWBOT's x265 Benchmark (fps)	**16.47**	16.03
PC Mark 8 Creative Test (Index)	**3,278**	3,184
CrystalDiskMark Sequential (MB/s)	**2,041/692**	494/349
Total War: Attila (Min/Avg fps)	12/**29**	**16/29**
3D Mark: Firestrike (Index)	6,668	**6,749**
Shadow of Mordor (Min/Avg fps)	**29**/33	**29/46**
Grand Theft Auto (Min/Avg fps)	**15/29**	13/**29**

All benchmarks are performed three times, and to the full length of their duration. Then, once results have been finalized, an average is calculated from each of the three runs. Best scores are in bold.

SPECIFICATIONS

CPU	Intel Core i7-6700HQ @ 3.5GHz
RAM	16GB DDR4 @ 2,133MT/s
Chipset	Intel HM170
GPU	Nvidia GeForce GTX 970M 3GB
Display	14-inch 2560x1440 display (matte)
Connectivity	3x USB 3.0, 1x USB 3.1 (Type C), SD card reader, RJ45 Ethernet, DisplayPort, VGA, HDMI, headphone and mic port
Storage	128GB PCIe NVMe SSD, 1TB HDD
Weight	3 lb, 12 oz

Don't let its looks fool you, there's one meaty machine beneath the hood.

Intel Core i3-6100

Dual-core 14nm monster?

SKYLAKE IS a curious little beast. On one hand, it's progressive, advanced, and capable of handling the gloriousness that is the Z170 chipset. On the other, it's pricey, doesn't offer a huge increase in performance over its predecessor, and was tricky to get hold of when it launched.

Let's be honest, this CPU isn't for gaming or high-end computing, certainly not for the vast majority of us. If you're reading this, you're either already well-equipped, or looking to get, at the very least, a Core i5 for gaming. If not Skylake, then Devil's Canyon or Haswell. So, what is this for? DIY NAS systems, Steam streaming rigs, sitting-room gaming stations, and home theater machines.

And what's the difference between the $140 Core i3-6100 and its $230 Core i5-6600 compadre? Well, the i3 features two physical cores versus the i5's four—though Hyper-Threading does bump that up to four logical processors—it has half the amount of L3 cache, and its TDP is 40W lower than its next of kin. Otherwise, you get the same Intel HD 530 Graphics, the same support for DDR4/DDR3, and the same access to those crucial 16 PCIe 3.0 lanes.

That doesn't sound like a lot, and when you consider that the Core i5-6600 has a base frequency of 3.3GHz against the i3's 3.7GHz, you're probably asking, why is the i5 so much better? It comes down to the limitations of logical cores. A good way to think of Hyper-Threading is like this: A physical processor is a mouth and a single hand. That hand can feed the processor once every cycle. Add Hyper-Threading, and you essentially add an extra hand (or a logical core), enabling you to use two hands to feed the same mouth. Although it's not as effective as having two mouths, it's still a lot faster than just using one hand.

HYPER-THREADING? PFFT

Does this show up in testing? Yep. In almost all our computational tasks, the i3-6100 was far slower than its i5 counterpart. In CineBench R15, the difference was close to 200 points. HWBot's x265 benchmark saw a difference of 5fps, and in game, over four separate titles, the average frame rate dropped by 13–15fps.

But, again, we have to ground ourselves. This isn't a triple-A gaming core. And it's certainly not a high-end processor for render workstations, either. Where the Core i3-6100's strength lies is within entry-level systems. It's great for older titles or less intense games, such as MOBAs and MMOs (we're looking at you, *WoW*). For an office and email PC for your grandma, it's ideal. And we can't forget about that power draw. Even with our meaty test system, featuring 32GB of DDR4, a Samsung 950 Pro, GeForce GTX 980, and Asus Maximus VIII Formula, under load the Core i3 pulled 22W less than an i5-6600K, and remained a constant three degrees cooler, too, making it ideal for a do-it-yourself NAS or HTPC.

Ultimately, the question has to be asked: Is this a good CPU? Well, that depends entirely on your perspective, and what you need. For HTPCs and living-room gaming, definitely; for AAA titles and gaming at 4K, definitely not; for hardcore simulations, 3D renders, and intensive applications, of course not. But you already knew that. For the price, it's a strong entry-point processor, a good all-rounder, and for that, we're more than happy to score the Core i3-6100 a solid "8." –ZAK STOREY

BENCHMARKS

	Intel Core i3-6100	Intel Core i5-6600K	Intel Core i7-6700K
CineBench R15 (Index)	393	591	**873**
HWBOT x265 Benchmark (fps)	10.3	15.5	**20.9**
WinRAR Archive Test—5GB (Minutes:Seconds)	5:17	4:08	**2:49**
Power Draw Idle/Load (Watts)	**62/277**	**62**/299	63/353
Firestrike (Index)	9,299	10,469	**11,293**
Total War: Attila (Min/Avg fps)	18/30	32/43	**35/47**
Batman: Arkham Knight (Min/Avg fps)	47/78	**64/93**	**64/93**
Far Cry Primal (Min/Avg fps)	21/40	**41/54**	**41**/53

Best scores are in bold. Our test system comprised 32GB (4x 8GB) Corsair Dominator Platinum @ 2,400MT/s, a GeForce GTX 980, a Samsung 950 Pro, a Samsung 2TB 850 Pro, all on an Asus Maximus VIII Formula motherboard, powered by a Be Quiet Dark Power Pro Platinum 1,200W PSU.

VERDICT **8**

Intel Core i3-6100

iPOWER Great NAS solution; good for streaming; capable office processor; low power consumption; support for Z170.

iSCREAM 14nm price point; not great for gaming with AAA titles.

$140, www.intel.com

SPECIFICATIONS

Base Clock Speed	3.7GHz
Turbo	N/A
Cores/Threads	2/4
Intel Smart Cache (L3)	3MB
Graphics	Intel HD Graphics 530
Graphics Clock	350MHz–1.05GHz
TDP	51W

AMD A10-7860K

AMD's most efficient processor yet

YOU HAVE TO HAND IT TO the red team. The company has managed to make the absolute most out of that 28nm architecture. Through revision after revision, we've seen power consumption and thermal TDP fall without the need for a smaller architecture. Yet efficiency isn't everything—performance is still king, and although the continued refinement achieved is impressive, it's that transistor size that is ultimately holding AMD back.

The AMD A10-7860K is a shining example of what you can piece together on a budget. It's not a processing powerhouse, but it's not meant to be. It's precisely aimed at the foreheads of everyday general computing and entry level gamers. We're sure a significant portion of readers are not interested in this tiny APU, but it's still an interesting and useful bit of hardware.

If you're looking for a quick and easy budget build for a friend, someone who enjoys MOBAs or simple games (in terms of graphical fidelity), such as *League* or *CS:GO,* this should be your first port of call. It's quite easy to assemble a machine with this at its heart for less than $335, including a tiny SSD, 8GB of RAM, a 1TB HDD, and a snazzy case. And for those titles, that's all you really need. And that's who this is aimed for: the budget builders.

As far as performance goes, the A10-7860K is a bit of a beauty, certainly for that $118 price point. Integrated GPU performance came out on top in comparison to all of Intel's offerings, at a whopping 1,211 points in Firestrike, almost 120 points more than Intel's HD520 graphical packages from the likes of the Core i7-6700K, and 300 points more than the entry level Core i3-6100. However, when it came to utilizing a dedicated GPU, the 7860K struggled, losing out by 2,000 points in Firestrike versus the i3-6100—a little disappointing, but not exactly too far from what we expected.

ONE FROM THE VOLTS

The real bottom smacker was power draw. Our test bench is nothing short of monstrous: 32GB of DDR3 at 1,866MHz, a GeForce GTX 980, two SSDs (500GB and 2TB), all running off a BeQuiet! Dark Power Pro Platinum 1,200W PSU. Yet even here, we only managed to pull 50W from the wall at idle; that's 12W lower than every Intel CPU we've tested so far. At load, it did even out a little, with the 28nm core pulling 300W total, matching it up with an Intel Core i5-6600K, but still impressive, certainly when you consider that DDR3 runs at 1.5V, as opposed to DDR4's 1.2V, and trust us on this one—that voltage change makes a difference.

Processing power, on the other hand, well, it's where you'd expect it to be. In our testing, it's about as good as one of the old-school Ivy Bridge i3s from yesteryear. Scoring 280 points in Cinebench R15, and taking a whopping nine minutes to fully archive our 5GB test folder, it's a bit of a bummer, but that's not what this core is for.

It's a low-powered integrated gaming processor, capable of playing entry level titles comfortably at 720/1080p. Hell, it would even work well as a mini HTPC for those looking at that route. And it gives us hope. Hope that AMD can take the lessons it's learned in optimizing processor design, and apply them to the zany 14nm architecture currently in development. Hope that, finally, it can give Intel a run for its money, and bring a little balance back to the force. –ZAK STOREY

BENCHMARKS

	AMD A10-7860K	Intel Core i3-6100
Cinebench R15 (Index)	280	**393**
HWBOT x265 Benchmark (fps)	6.6	**10.3**
WinRAR Archive Test—5GB (secs)	546	**317**
Power Draw Idle/Load (Watts)	**50**/300	62/**277**
Firestrike Integrated (Index)	**1,211**	909
Total War: Attila (Min/Avg fps)	10/18	**18/30**
Batman: Arkham Knight (Min/Avg fps)	35/61	**47/78**
Far Cry Primal (Min/Avg fps)	**30/45**	21/40

Best scores are in bold. Our test system comprised 32GB (4x 8GB) Corsair Vengeance LPX @ 1,866MT/s, a GeForce GTX 980, a Kingston 512GB HyperX 3K SSD, and a Samsung 2TB 850 Pro, all on an ASRock Fatal1ty FM2A88X Killer motherboard, powered by a Be Quiet! Dark Power Pro Platinum 1,200W PSU.

VERDICT **7**

AMD A10-7860K

ZENITH Hugely efficient for 28nm; great for entry level gaming; affordable.

NADIR Not a number-cruncher; struggles with dedicated graphics; relatively inefficient compared to performance.

$118, www.amd.com

SPECIFICATIONS

Base Clock Speed	3.6GHz
Turbo	N/A
Cores	4 CPU, 8 GPU
Cache (L2)	4MB
Graphics	Radeon R7
Graphics Clock	757MHz
TDP	65W

HyperX Cloud Revolver

Return of the king?

LET'S CUT TO THE CHASE—if you're after the best bang for your buck, there's little doubt that HyperX Cloud headsets are monstrously good value for money. With an incredibly wide soundscape, great comfort, and options for both 3.5mm and USB connections, you'd be hard pushed to find anything better for the price.

So why did they need an update? Well, the original Clouds that Kingston developed were actually a design sold to the company by a Swedish manufacturer known as QPAD. In short, the Clouds were QPAD's QH-90s. However, once Kingston got the design into the lab, it bumped up the bass a fraction, dropped the price (taking a hit on the financial side), and generally made the sacrifices necessary to provide us with an exceptionally well-rounded pair of cans for all of our gaming and musical experiences.

In short, the Revolvers are HyperX's (now a separate brand from Kingston) first unique iteration of the Cloud headset. But don't fear—these babies are still built from the ground up to encapsulate everything we loved about the originals, yet in a new design, with a few extra tweaks under the hood to ensure we get the best possible sound for our little lugs to enjoy.

Overall, the Revolvers are incredibly comfortable. The intuitively designed headband relieves pressure from the top of the head, and requires absolutely minimal adjustment to get it to sit just right. Interestingly, despite their outward appearance, the Revolvers are actually open-backed, with small air intake holes hidden behind that extruded logo. What this does is open up the air around the drivers, providing a better sound for the listener, yet without suffering from a huge amount of sound leakage. On top of that, you get an impeccably good removable microphone, which adjusts easily and holds its form impressively well.

Similar to our headset group test two issues ago, we tested the Revolvers through the Denon DA-300USB external DAC, but with one major difference: We compared them to the absolute *crème de la crème* of headphones, BeyerDynamic's DT1770 Pros. An unfair test? Most definitely; after all, the Beyers (beside being our favorites), are four times the cost of this little underdog.

POWER RANGERS

How did they do? Well, the Revolvers have an incredible range. The upper heights of the treble are immense—very impressive for a gaming headset. At times, they sounded as crisp as the DT1770s, but the bass was just a touch more powerful. Unfortunately, this did impact the mids, muffling some of the smoother tones you get in acoustic music. Metal, punk, and synthetic tracks all sounded great—punchy and bouncy—thoroughly enjoyable, thanks to the Revolvers' beautifully well-rounded soundscape. If anything, the Revolvers' enhanced treble did give them a bit of an overly synthetic feel, stripping the token warmth we expect from something a little more audiophile-focused, but for $120, the sound quality is stunning.

In game, the Revolvers were sharp, still nipping at the jaws of that treble. FPS games benefitted the most from the enhanced sound signatures. They made the explosions truly piercing, and gave you a thoroughly enjoyable sense of immersion. *Star Citizen* was solid—at loud volumes, the rumble and thunder of the engines, and the energy weapons glancing off your hull, were truly fantastic. More than a match for the Beyers.

What about compared to the old Clouds, though? Well, the Revolvers definitely had the edge when it came to treble—the soundscape was deeper because of it, yet not enough to pull it out too far in front. The real problem with these two is that they both sounded excellent. We didn't prefer one to the other, yet both had a unique sound (in contrast with their aging sibling). On top of that, overall comfort fell into that same box. The original Clouds are a snug fit; there's a sense of security about them, as they close you in and hug you tightly. The Revolvers fitted just as well, but it was all about that light sensation: very relaxed, very centered about distribution of weight, and an openness that the original Clouds just don't have.

Certainly, from an aesthetic standpoint, the old-school Clouds have far more class—they're sharp, smooth, and elegant. The Revolvers, on the other hand? Well, they've got that gaming flair about them—which isn't going to be for everyone.

Ultimately, the Revolver and Cloud II could trade blows with each other all day. It's a battle of the ages, but if you're after a sound gaming headset, you can't go wrong with either of these offerings. Well done, Kingston HyperX! Oops, we mean HyperX. Ahh, whatever.... **–ZAK STOREY**

VERDICT **9** KICK ASS!

HyperX Cloud Revolver

MAGNUM Great soundscape; not typical gaming headset; comfortable; holds its own; removable mic.

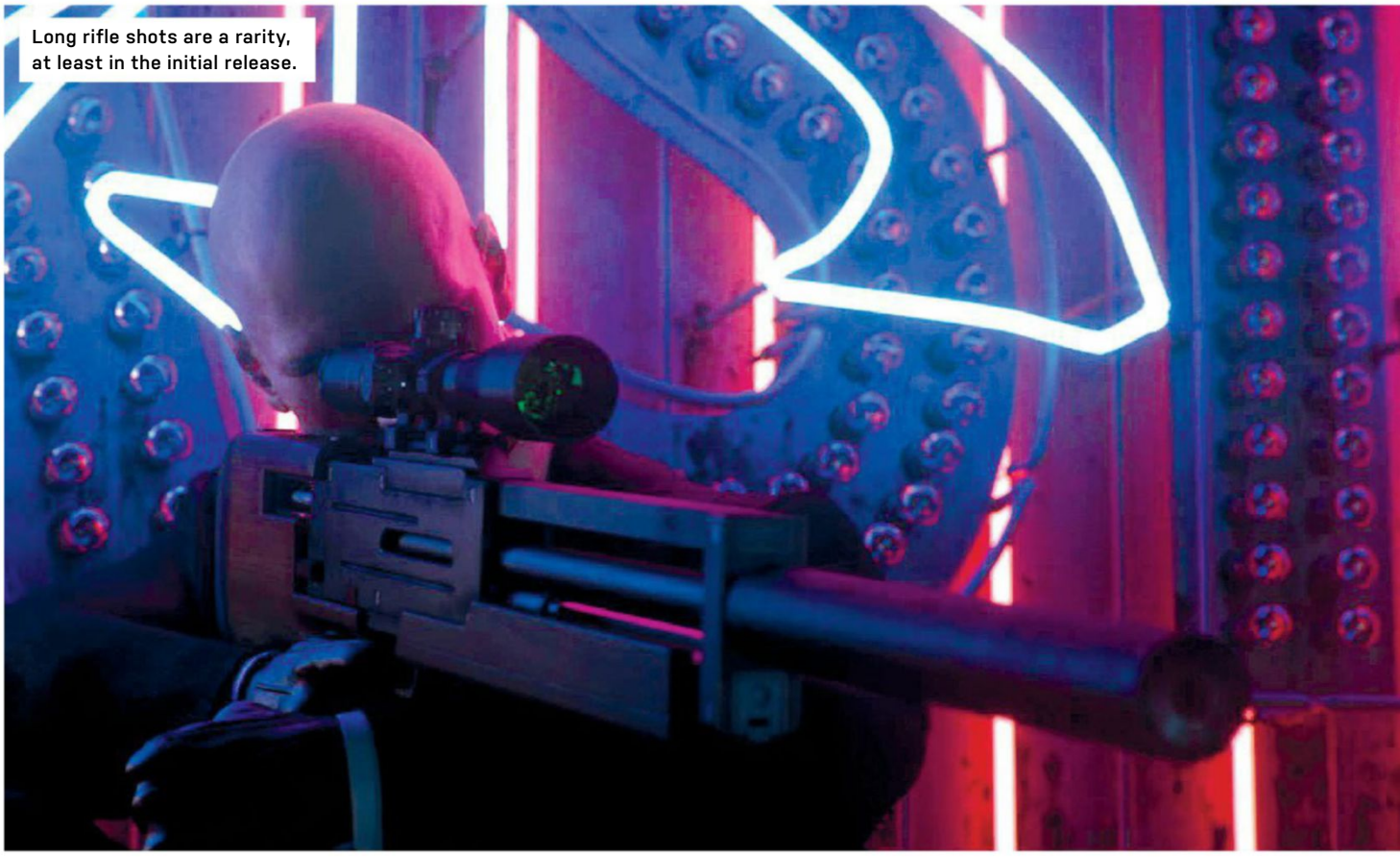
REVOLVING DOOR Pricier than Cloud IIs; no USB adapter.

$120, www.hyperxgaming.com

SPECIFICATIONS

Driver Technology	50mm, Dynamic
Frequency Response	12Hz–28kHz
Impedance	30 ohms
Connectivity	3.5mm, 4-pole
Microphone	Unidirectional noise canceling
Weight/With Mic	0.79 lb/0.83 lb

It's all about that bass, about that bass....



Long rifle shots are a rarity, at least in the initial release.

Hitman: Intro Pack

Where a man with a barcode tattoo raises no suspicion

HINDSIGHT BEING WHAT IT IS, the decision to move IO Interactive's choke-'em-up series to an episodic release model may prove to be a masterstroke. It's impossible to tell right now, of course, with only the tutorial and first level in our hands, but one thing is clear: By limiting your progression, the game forces you to play it "right."

The idea that there are right and wrong ways to play a game is one that's frequently kicked up and down the debating halls of the Internet. If we send *XCOM 2* into a loop of waiting until the Avatar Project is nearly complete before finishing a story mission and setting the clock back—putting off triggering the final missions that end the game—are we doing it wrong? Is it enough simply to progress in a game, or is it necessary to do it well?

Hitman was always a series that could suffer from this. Its levels, with their multiple routes, completion rewards, and performance ratings, could often be completed by racing through with a machine gun. A messy performance might not win you the golden Silent Assassin rating, but it was a legitimate way to play, and would advance you to the next level.

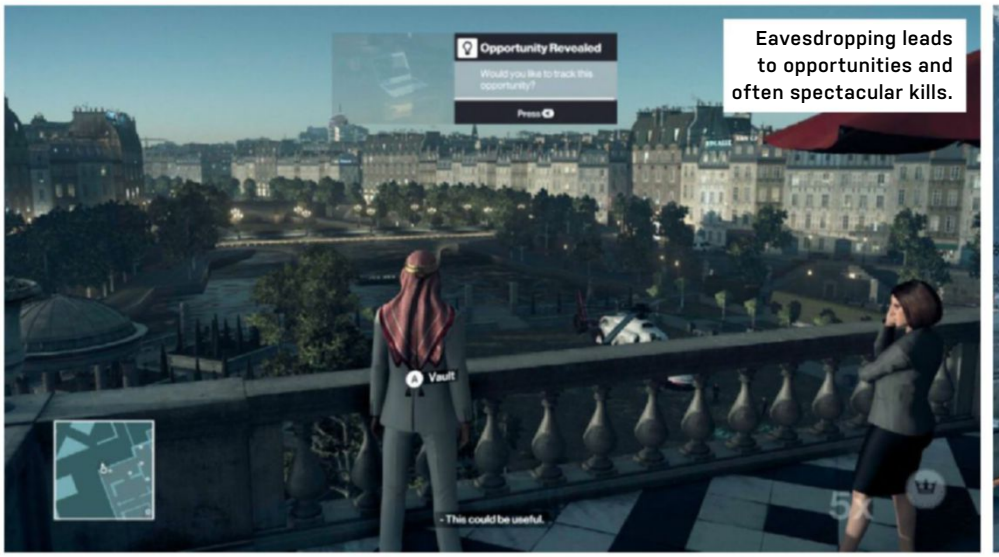
But when there is no next level, you're forced to stop and think. Do you pay your money, rush through the limited content on offer, then leave it in your Steam library until the next one is released? There's always another game on the horizon, after all. Or do you play the level over and over, getting to know its shady corners, the hedge lines you can run along unseen, and the mechanical patterns of the guards? You can pop a silenced pistol shot into a target for an easy kill, but this leaves you open to discovery—so try that, but later go back and poison his champagne, drop something on his head, or make a bomb go off. Maybe drown him in the toilet, too. Then slip away before anyone even knows you were there.

Perhaps the epitome of this kind of gameplay was Bizarre Creations' long-forgotten, third-person shooter *The Club,* which scored everything you did and challenged you to repeat the experience to get a better score. The only links between it and *Hitman* are the camera position and the guns, but they share the compulsion to go back and do better. To get it right.

The training missions you undertake, in a strange mix of psychiatric interview and party boat, do a good job of introducing the game's systems, such as avoiding recognition by those you're meant to blend in with—a great step up from previous game *Hitman Absolution,* where you'd avoid anyone dressed the same as you. Now, only middle-management goons know you're not one of their staff, and are handily marked out for you to plan a route around.

(Talking of *Absolution,* it's quite possible that you may not have played any *Hitman* games other than that one—they're not all like that. The linear *Absolution,* infested as it was with sexy nuns and wrestlers, and with a startling lack of save points, wasn't the best installment in the series. For that, you need to go back to 2006 and *Blood Money,* a more open-ended experience, and the template for 2016's *Hitman* to follow.)

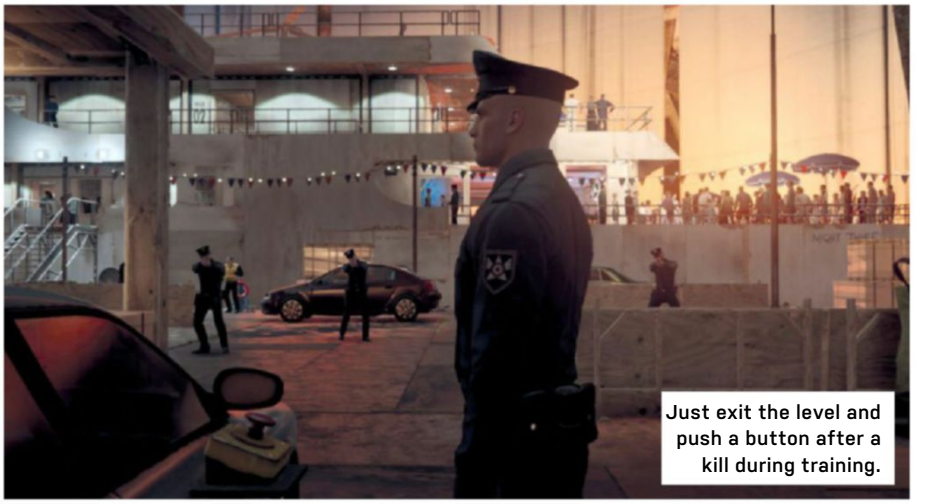
The clockwork nature of *Hitman's* NPCs —and there are a lot of them, both in the tutorial and the Showstopper mission set



Eavesdropping leads to opportunities and often spectacular kills.

This year's 47 doesn't seem to know what to do with his hands.

This fighter jet can be rigged for rocket-assisted murder.

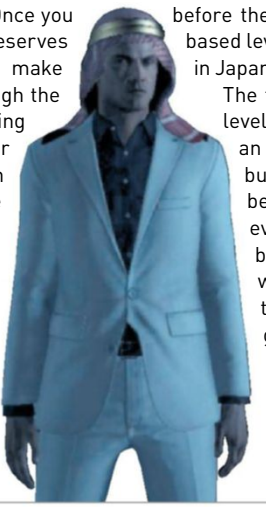


Just exit the level and push a button after a kill during training.

in a Paris fashion show—makes them ripe for exploitation. Throw a coin and a guard investigates, making it easy to squeeze his neck, put on his uniform, and take his place. Leave a gun on the ground, and a guard moves it to a "safe" place, deeper in the level, from where you can later retrieve it.

TARGET PRACTICE

While the tutorials are small, enclosed affairs, Showstopper is huge. Once you think you've exhausted its reserves of murder, you can go on to make things worse for yourself through the new Escalation missions, adding supplementary rules that alter things further. The game can drop Elusive Targets into the mix, too, giving you 48 hours to take out someone who's not marked in-game, but who you must identify from limited information—possible thanks to a graphics engine that's sharp enough, and capable of using DirectX 12, even if we'd stop short of calling it a graphical powerhouse. User-generated Contracts, *Absolution*'s best feature, return too.



With missions geared toward this level of replayability, our concern is whether IO Interactive can keep up the pace. The next installment, set in an Italian coastal town and due for release in April, looks to be equally enormous, if not even bigger than Showstopper. May will take us to Morocco, before the release of Thailand and US-based levels, with the game concluding in Japan nearer the end of the year.

The tutorial shows that a compact level can work, especially with an explosive pay-off at the end, but expectations are going to be high for enormous levels every time. IO must work to balance these expectations with tight, satisfying gameplay to avoid releasing a honking great goose of a level that isn't enjoyable to kill within.

If a balance can be struck, this return to *Hitman's* pre-*Absolution* roots could be a real contender. Agent 47's menacing walk sets the pace—take it slow, think about your moves, try things out, and become intimately familiar with each level's possibilities. It has its flaws—online and offline modes with incompatible saves being one; the glitch that saw our target seemingly imprisoned inside another NPC, and unable to leave a room despite our best attempts at luring, being another. Despite this, *Hitman* could be game of the year, if it can keep up the level of its execution. –IAN EVENDEN

VERDICT **8**

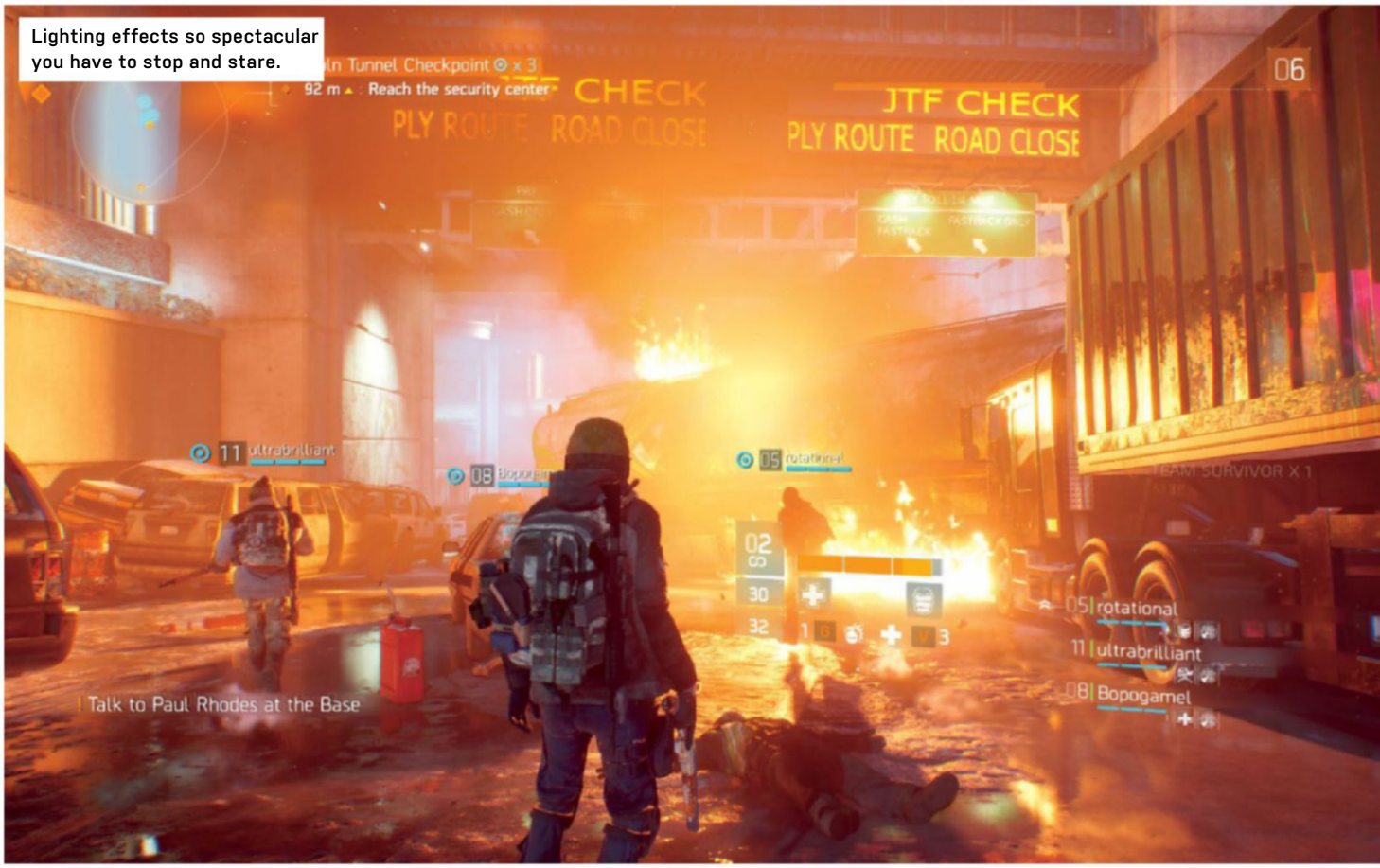
Hitman

STABBING Intelligent level design; satisfying systems; clever killing is fun.

BLEEDING Graphics are fine but not amazing; level replaying will alienate some.

RECOMMENDED SPECS Core i7-3770K 3.4 GHz/AMD AMD FX-8350 4 GHz, 8GB RAM, Nvidia GeForce GTX 770/Radeon R9 290.

$15/$60, www.hitman.com, ESRB: M



Lighting effects so spectacular you have to stop and stare.

Tom Clancy's The Division

Can you save New York from a virus? Do you want to?

TOM CLANCY MAY BE DEAD, but his world-vision marches on. *The Division* is a multiplayer shooter based in his alternate version of New York, where virus-laden dollar bills are distributed on Black Friday and decimate the population. You take the role of a member of The Division—a super-secret set of sleeper agents scattered throughout the population, ready for an emergency. Like most of Clancy's games and novels, the hero's talents lie solely in violence.

Players roam an open-world New York, battling anyone wearing a hoodie, righting wrongs, and trying to get the infrastructure back online, so the government can lift the quarantine on the city. You can either solo your way through it, team up with friends, or just matchmake with other random players to complete the missions. You can focus on the story or simply wander the wonderfully realized world.

So, beneath its shooter clothing, *The Division* is an action MMO. Enemies are all leveled, and fighting them beyond your level is tough—but even same level ones are bullet sponges. Each enemy fits an archetype, from snipers to grenadiers to the hugely annoying rushers, who just charge at you. These all come in harder veteran flavors, designed for group play, and with named bosses—often with hilariously commonplace monikers, such as Mitch or Wayne—who require many, many clips of ammunition to take down. There are also rival factions—such as the pyromaniac Cleaners—aiming to clean up the city, conquer it, or take it apart.

Despite those MMO roots, it also draws on Ubisoft's long history of tactical combat games made with Clancy, such as *Rainbow Six* and *Ghost Recon*. Flanking and teamwork are key to taking down hard targets, but most crucial is using cover. It's a classic cover shooter, where you're constantly moving locations to avoid getting surrounded, and hoping to flank the enemy. A very nice cover movement system allows you to point the camera at another piece of cover and automatically move there. Stay out of cover for more than a few seconds, and you'll be as dead as the dodo.

That said, as we implied, the combat isn't particularly innovative—which we guess is by design. It's rough small-arms fire from cover, using a trio of weapons (but the ability to carry something like 30, all of which are familiar weapon types, and doubtless licensed from gun manufacturers). It's like a comfort food among a smorgasbord of unusual treats. These include an endless RPG system, which is always giving you new stuff in reward for your shooting performance—new weapons, perks, armor, clothes, abilities, talents, and so on.

It also draws on Ubisoft's recent history of open-world games, such as *Assassin's Creed* or *Watchdogs*. As you traverse the map, you encounter areas designed for different levels of player, with safe houses at the core of each. Explore these safe houses and they act as respawn points, as well as displaying tons of missions and side quests in the nearby area. Everywhere you go are bits of story, from radio messages to


Each wing of your base has its own storyline.


The level of detail is gobsmacking.


Much of New York is peaceful and familiar.

The city map is seamlessly useful.


Violent traces appear around the city.

strange floating vignettes to texts, further explaining how the city fell apart.

One of the most innovative elements is the UI, which partly floats in the world—much like it was promised to in *Watchdogs*. For example, a mission entrance will have a floating holographic barrier in front of it, telling you its title, level requirements, and prompting you to press "G" to automatically matchmake. Elsewhere, the inventory system is a mess, and it's not clear what you can do in the field or in your huge upgradable base. It's an ambitious system, but it doesn't quite work—sometimes bits of it are floating behind you or above you.

IT'S A WONDERFUL WORLD

It also serves to obscure the world Ubisoft has created, which is stunning. The Ubisoft open-world development machine, which encompasses thousands of people across dozens of countries, is really showing what mass-scale game development can achieve. This abandoned Manhattan feels unexpectedly real, from the abandoned cars and firetrucks to the wandering civilians, confused dogs, and misguided looters. Sometimes the scenes are spectacular—a firefight in a burning department store, decked out for Christmas. Other times, they're familiar but given a twist—sewers, apartments, offices, and the like. And the team does make effective use of New York and its iconic buildings—though the parallels with 9/11 from locations such as memorial walls may unsettle some.

All that said, what *The Division* was first sold on was its betrayal mechanics—the potential to screw over your teammates (and hence the double-meaning name). Yet these *DayZ*-evoking PVP elements are restricted to the Dark Zones—areas that in the fiction are so heavily contested that the peacekeeping agencies have abandoned them completely. Here the game we were promised takes place, where players can team up or betray each other for the greater rewards available in the area, which are snatched from the tougher local AIs.

These rewards can only be extracted by helicopter, in highly-contested, AI-populated areas—and the flare to call a chopper also lets any other player in the area know that someone's trying to escape with their loot, prompting them to descend on the location. During our Dark Zone play time, we didn't experience much betrayal or even teamwork, but we've had tales told to us of teammates backstabbing each other.

What's your motivation to level up? Well, theoretically, to find out more of the story through higher-level story missions—but the story is so so-so that it's not really a motivation. Perhaps it's to get better clothing? Well, not really—everyone is dressed for a New York winter, which means identikit duffel coats and sensible boots. Is it to get better weapons? Is it really the case that you're killing people to get better weapons to kill people more easily? It does appear to be—which, after all, was the same tight loop that *Destiny* had.

This is only an early review of the game—the developer Massive promises much more content over the coming months. At the moment, it feels like a multiplayer shooter version of *Escape from New York*, albeit without the 80s humor or style, and with a lot of smarts added in. It's easy to play, easy to team up, easy to betray, and easy to put down. –DAN GRILIOPOULOS

VERDICT **8**

Tom Clancy's The Division

INSPIRED Gorgeous setting; fun team gunplay; smart PvP area; huge amount to do.

TIRED Storyline could do with work; occasionally buggy combat; boring clothing and character options.

RECOMMENDED SPECS Intel Core i7-3770 or AMD FX-8350; 8GB RAM; Nvidia GeForce GTX 970 or AMD Radeon R9 290; 40GB storage.

$60, http://tomclancy-thedivision.ubi.com, ESRB: M

LAB NOTES

JIMMY THANG, ONLINE MANAGING EDITOR

Maximum Thankfulness

Until next time...

300. That's roughly the number of both articles I've written and videos I've published during my tenure at *Maximum PC.* That's a lot of content, and I also think it marks a pretty good number to end on.

Working at *Maximum PC* has been the greatest job I've ever had. As a PC geek and technophile, I've been fortunate enough to have my dream job. I've been able to sit down and eat dinner with Microsoft's Phil Spencer, play co-op VR with Oculus founder Palmer Luckey, and even become a meme with Valve's Gabe Newell. I also got a chance to see the world. The best part, however, is getting to work with the crew that steers this ship. The people I've worked with are very passionate about their jobs, and I hope it shined through with every word you read.

When I applied to work at *Maximum PC,* I didn't know what the future held for the PC platform. This was in 2012, when the world almost collectively said that smartphones and tablets would kill the PC. But four years later, the enthusiast PC market is not only healthy, but stronger than ever.

Through the power of the PC, those four years brought us the advent of modern VR, a glimpse of mind-blowing AR, amazing 3D printing technology that's been able to help people get replacement limbs, and countless other tales of technological innovation that can only be done through the raw processing power of the platform.

The PC has been around for ages, but it's still leading technological innovation. Meanwhile, where have tablets gone? If you look at sales charts, pretty much straight off a cliff, and smartphones now only boast small incremental improvements. Yawn. The PC has innovated and evolved. Do you want a laptop that can transform into a tablet? There's a PC for that. Do you want to mine bitcoins? There's a PC for that. Do you want to enter VR? There's a PC for that, too.

Thanks for the "memeries."

I've never been more proud to be a part of the PC industry, and as I move forward in my career, I'll always have *Maximum PC,* and you, to thank for allowing me to become part of it. Thanks for coming along for the ride.

ALEX CAMPBELL

Associate Editor

I met with Razer in March for a demonstration of a new line of keyboards. As we were sitting in the room waiting for the demo, the idea of e-sports in VR came up. Now, I'm no pro at *Rocket League,* but think just for a moment about the idea of watching a *Rocket League* match. How would you watch? Twitch, probably. Now imagine sitting in a virtual stadium in VR, watching the match unfold in front of you. You could see the avatars of your friends if you look left or right. It would be like going to a football game, but for computer games. That's awesome. Even my mom could watch a *Rocket League* game in VR, if it were this accessible. If e-sports really want to take off, this is a great way to do it.

JARRED WALTON

Senior Editor

This year's GDC could have been renamed VRDC, because you couldn't swing a wired mouse without clubbing someone wearing a VR HMD. Having watched the movie *Everest,* getting to experience traversing Hillary Step in Solfar's *Everest VR* was amazing—and without any altitude sickness or risk to life and limb! I tried walking off the edge for fun, but sadly I ended up floating in the air. Crytek's *The Climb,* in contrast, lets you fall, but only for 1.3 seconds before fading to white—apparently, falling 10 seconds and hitting the ground in VR is a recipe for serious nausea. Next up on my plate: figuring out ways to objectively rate VR headsets and run some VR benchmarks. Stay tuned!

Editors' Picks:
Digital Discoveries

Jarred Walton, Senior Editor, and Alan Dexter, Executive Editor, discuss their latest finds

SAMSUNG T3 1TB

I love digital speed, whether it's in the form of a new CPU, a faster graphics card, or a screamingly fast NVMe SSD. One thing that routinely gets me down is when I get a new gaming notebook in the office for reviewing, and I need to copy all of my testing files over to the new system. Currently, that means 350GB of data, which takes more than an hour over Gigabit Ethernet, or around three hours via 802.11ac. There is a better solution: an SSD attached via USB 3.0.

Samsung recently updated its portable SSD line, moving from the plastic shell of the T1 to an aluminum shell with its new T3. The range also changed to a USB Type-C connector, though it's still only 5.0Gb/s. The company also uses its new 48-layer V-NAND chips, which allow for up to 2TB in the T3. While the 2TB model would be lovely, in practice I'm fine with the 1TB drive—until my test suite balloons past the 1TB mark. This cuts the copy time down to just 26 minutes, and if you're moving large files rather than lots of small files (my test suite consists of 35,000 files), it would go even faster.

The only drawback, other than the $400 price, is that you'll also need an SSD for your main drive. Otherwise, you'll run smack into the HDD speed limit.

3DMARK LEGACY

When you've been reviewing graphics cards for as long as I have, you can build an attachment to the tools you use. 3DMark is a name that should be familiar to most of you, because we use a couple of the latest versions to test systems to this day, but I still remember running the first version back in 1998. Specifically, I vividly remember the *Wipeout*-inspired racing test from 3DMark99, and the promise that it held for PC gaming.

We never did get the *Wipeout* that was hinted at in that first benchmark, even though we've gone well beyond the graphics complexity needed to render it convincingly on our PCs. The same can be said for nearly all the game sections in Futuremark's benchmarks—whether that's the lush forest inhabited by fireflies, steampunk dirigibles, or trolls playing a game of stones. We have seen plenty of shoot-'em-ups, though, so it's all good really.

You can grab these legacy benchmarks from www.futuremark.com/benchmarks/legacy, although getting them running isn't always as straightforward as you'd hope—Windows 10 refuses to run my beloved 3DMark99, for example, but I'm sure there's an old machine here somewhere that'll be able to run it. Now, if you'll excuse me, I'm off to see how high a frame rate I can get....

GEEK TESTED & APPROVED

Ultrasabers Renegade LE

WHEN I FIRST WATCHED the trailer for *The Force Awakens,* and saw the new controversial crossguard lightsaber, I hated it. Upon seeing the movie, however, I admit that I walked away pretty impressed. So when Ultrasabers told me it was going to send me Kylo Ren's lightsaber, I was quite excited.

It came in two packages: one for the hilt, and the other for the three beam portions of the saber. This means that some assembly is required, but it took me all of five minutes to put it together.

Once you have it up and glowing, you'll notice two things about the saber. Firstly, it looks really badass. The red light is extremely bright. The handle is also made of aluminum, and looks like it could be straight out of the movie. Secondly, it's heavy. In terms of dimensions, it has a 1.5-inch wide grip, is 11.25-inches wide, and 16.5 inches tall.

Of course, no lightsaber would be complete without the "vroom" noises. Thankfully, the Renegade LE features a bottom-mounted speaker that sounds good and plenty loud. The only downside is that you do have to swing the entire hilt to get the sounds to register. The saber also makes cool clashing noises as well.

The lightsaber isn't perfect, however. The two included 3.7-volt batteries in the Renegade LE lasted under an hour out of the box. When we tried to recharge them, we noticed that the batteries got stuck in the hilt, and we had to bang the bottom of the saber on the floor to pop them out. Also, for $330, the top beam should come out before the side beams, just as the saber lights up in the movie.

In the end, if you're looking for a beautiful lightsaber that looks legit, you could certainly do worse than Ultrasaber's Renegade LE. **–JT**

$330, www.ultrasabers.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Mobo/CPU Suggestions
> Laptop Graphics
> Biometric Security

Pimp My Rig

I'm building a new PC, and would like your advice on a great mobo/CPU combo. I don't game, but I spend a lot of time on the Internet watching videos, shopping, and doing research. It's not unusual for me to have 20–30 tabs open for long periods of time (plus Word, Excel, Quicken, and so on). I need a system that's not going to choke with all these applications open, and I'm looking at Intel's Core i7 processors. Money isn't a problem, but I don't want overkill just because I can afford it. What do you suggest? Should I wait for one of Intel's newer CPUs? I plan to use two SSDs in RAID 0, a separate HDD, 16GB RAM, onboard sound, a nice GPU, and Windows 7. I have Verizon FiOS 75/75 for broadband. **–Tim K**

SENIOR EDITOR JARRED WALTON RESPONDS: Hi, Tim. You may be surprised to hear that your demands aren't that demanding. My daily driver PC is a laptop sporting a Core i7 processor, with 16GB RAM, and a 512GB SSD. I do 95 percent of my work on this laptop, because I can pick it up and take it with me as needed. Right now, I have 41 tabs open in Chrome, Word and Excel are sitting in the background, and I've got a few other applications running as well. It handles all of this without too much trouble; the one potential drawback on occasion being the Intel HD 4600 Graphics on the CPU. (The laptop has a GT 750M graphics card, but it doesn't usually kick in unless I load a game.)

As you don't game, you can use just about any Core i7 (or even Core i5) processor, toss it in a decent motherboard, then you're set. If you find you need H.265 hardware decoding support in the future, add a graphics card, but I've never needed that. If you're looking for specific recommendations, I'd buy a Core i7-6700K, as it's always nice to be sure your CPU isn't a bottleneck. Put that in a decent Z170 motherboard, such as the Asus Z170M-Plus (mATX) or MSI Z170A-G45 Gaming (ATX), and you should be set. Note that the MSI board includes more features, such as dual M.2 slots, but if you're only using a single M.2 drive, there's not much need to go further.

The only other advice I can offer is to look at the motherboard's approved memory list to ensure compatibility, and you'll want to check for a BIOS update before getting too far into the software installation. Waiting for future hardware releases is pointless. AMD's Zen still

CUT, COPY, PASTE

* In our April 2016 issue, we mistakenly identified the Sager NP9870-S laptop's model name as NP8675-S. We apologize for the error. You can read our corrected review online (http://bit.ly/MPC_NP9870-S).

* In our May 2016 issue, we got over-excited about the capacity of the Samsung 850 Evo M.2 in our budget gamer. We love the idea of an 8.25TB SSD, but reality hasn't quite matched our dreams yet. It should just be a 250GB drive.

[NOW ONLINE]

OVER A DOZEN RIFT LAUNCH TITLES ON DISPLAY

We recently had the opportunity to attend the Oculus Rift launch preview event in San Francisco, which took place during GDC, and got to play over a dozen of the Rift's launch titles. This event had over 30 full-fledged games, and most of the titles that we tried felt fun and polished. The games were all pretty different, too. You can check out the games we played on line at http://bit.ly/MPC_OCUPrev.

Multiplayer shooter *Dead & Buried* is Touch-only.

↘ submit your questions to: comments@maximumpc.com

looks to be late 2016 at best, and Intel's Kaby Lake will probably be a higher clocked variant of Skylake (aka, Devil's Canyon, take two); Broadwell-E is only important if you need lots of CPU cores.

Play Power

I've been reading the magazine for years and I like the direction you're going in. The last two years I've probably been one of your few subscribers in Zambia, where I've been serving in the Peace Corps.

I bought a Gigabyte P-34 laptop with an 860M about a year ago, and it's served my FPS needs reasonably well. I'm moving home in a few months and thinking about what my next gaming rig will look like.

After falling in love with the IPS version of Asus's ROG Swift in the February issue, I'm thinking of starting with that, and building a similarly kick-ass system to power it in the following few months.

Will my puny 860M be able to push enough pixels to power an ROG Swift in the meantime, while I put together a stronger system? **–Alex**

SENIOR EDITOR JARRED WALTON RESPONDS: Hi, Alex. There are lots of good laptops with IPS displays, so it's not difficult to find a decent gaming laptop. I like Gigabyte's clean aesthetic, though they can get warm under load on higher-end models (lots of performance in a small package is difficult to deal with; Razer and others have similar issues). You do need to consider that there aren't many upgrade paths with laptops, short of selling your old laptop and buying a newer one, so get the best GPU you can afford.

Depending on budget, the GTX 970M is a good starting point for 1080p gaming, while 980M is more forward-looking, but we should see faster mobile GPUs in the fall releases. Can your GTX 860M handle games until then? That depends on what games you want to play, and how low you're willing to go on the quality settings. I've got an older laptop with a GT 750M, which is a dinosaur in the graphics world. *Fallout 4* is still playable at low quality, which looks quite a bit worse than medium and above. Other games are in a similar state. The GTX 860M is a healthy step up from the 750M, so 1080p medium quality or better is doable.

There's often an OCD complex among gamers, where the inability to max-out quality settings drives us a bit bonkers, but having tested a lot of games over the years, I can honestly say that gameplay trumps graphics all the time, and if a game is fun and runs well at medium settings, you'll be happy. After all, that's what console gamers live with! And if you run across a game that's beyond the abilities of your laptop, that's when you should really start looking at upgrading.

Key Is Under Mat

Something significant is being overlooked in the debate about the FBI asking Apple to supply a backdoor into the San Bernadino iPhone. The recent models of iPhone, and many other smart devices, already have an effective backdoor: fingerprint scanners or other biometric functions that work just as well with sleeping, unconscious, and/or dead people.

Vendors of devices, who are conscious of the privacy and security of consumers, should tell them not to turn on the biometric functions. Authorities that want the biometric backdoors kept open, should tell consumers to keep them turned on. And consumers who are concerned about privacy and security should refrain from activating these backdoors.

–Hitoshi Kokumai

SENIOR EDITOR JARRED WALTON RESPONDS: Hi, Hitoshi. You're correct that biometric security can be easier to bypass than a PIN or password, especially on phones—it's there almost purely as a convenience. The iPhone 5c in the San Bernadino incident didn't support biometrics, and anyone serious about keeping their phone locked down should realize the problems with biometrics. But if you just want a pseudo-secure solution, the convenience is hard to overlook.

For most users, I don't think we do anything nefarious where we even worry about someone getting access to our phone. If someone pulled a gun or knife on me, and demanded I unlock my phone and give it to him, I'd comply—there's nothing there worth risking life or limb to preserve. Thank goodness I'm not in the espionage business! But corporations and other entities worried about security would do well to understand the inherent issues with most biometric solutions.

And criminals and terrorists should all use biometrics and easy-to-guess PINs, please!

Facebook Polls

What's your rodent of choice, and why?

Sina Hamedian: Logitech MX Master for life. Before that, I used its predecessor, the Logitech Performance Mouse MX. They just feel great in the hand, which is essential if you have to work in front of a computer for hours at a time.

David Thomas: I've been using the DeathAdder, in some variation, for my entire PC gaming life.

Osark Heirofserranevada: I've been using a cheap Legend Gaming Mouse for years. The company has gone out of business, which is a shame, because it's the equal to most $50 mice.

Ace Saunar: The Logitech Proteus Core, because it is just too damn sexy.

Ryan Hoffman: The Logitech M500. I trust a wireless mouse like a snake in a rat nest.

James Cheek: A Zelotes T-80 Big Mac. Best $10 I ever spent: 5,500 dpi and bright LED lights.

Todd Kay: Logitech G700. Best I've ever used.

Dave Cooper: Logitech Proteus Core. Love it.

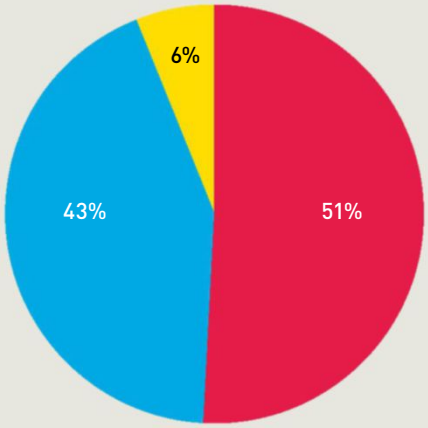
Mark Rathbun: Mad Catz Cyborg RAT7—I have worn out two since you rated them "9 Kick Ass."

William O'Meallain: Old Logitech G5 with removable weights. Nothing better. Of course, on my retro-rig, I rock the Logitech Force Feedback.

Xavier Jorgensen: Microsoft Explorer trackball. Primary movement with the index and middle, buttons with thumb, ring, and pinky.

John Phillips: Corsair M65. Simple, affordable, programmable, comfortable, customizable, cool.

In the DirectX 12 versus Vulkan battle, which side are you rooting for?



51% DirectX 12
43% Vulkan
6% Neither, I want a third contender in the fight!

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THE BUILDS

BUDGET GAMER

INGREDIENTS

PART		PRICE
Case	Cooler Master Elite 110	$40
PSU	SeaSonic SSR-450RM NEW	$80
Mobo	Gigabyte GA-H170N-WIFI	$115
CPU	Intel Core i5-6500	$205
GPU	Gigabyte GeForce GTX 960 Windforce 4GB NEW	$200
RAM	8GB (2x 4GB) G.Skill Ripjaws V Series DDR4-2133 NEW	$36
SSD	250GB Samsung 850 EVO M.2	$85
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit	$16

Approximate Price: $777

HOLY H170. We were surprised to arrive at this divine triplet of a price for more reasons than the triple sevens alone. We made a couple of interesting changes to this month's build, but first let's talk prices.

While we've seen prices go up and down for the Samsung 850 Evo, we were surprised to see the drop for DDR4. We've seen 8GB kits hover between $40 and $50, but this time, the price dipped to $36.

We ended up with a SeaSonic PSU. While SeaSonic isn't a big gaming brand, it makes solid PSUs, and this one didn't cost much more than the Corsair CS450M we had before. (SeaSonic also makes PSUs for other companies that get rebranded.) We also changed our GTX 960 to make use of Gigabyte's shorty Windforce model, instead of EVGA's trusty 1962-KR. It's about $10 cheaper and can offer comparative performance. Just stick with the 4GB GTX 960 to make sure you've got enough VRAM for all those textures and shaders.

MIDRANGE

INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Pro M	$80
PSU	EVGA SuperNOVA G2 650W	$101
Mobo	Asus Z170-A NEW	$155
CPU	Intel Core i5-6600K	$274
Cooler	Corsair H80i v2	$87
GPU	XFX Radeon R9 390 NEW	$320
RAM	16GB (2x 8GB) Corsair Vengeance LPX DDR4 2400 NEW	$65
SSD	500GB Samsung 850 EVO M.2	$158
HDD	Western Digital Black Series 2TB 7,200rpm	$122
OS	Windows 10 (*Download*)	$110

Approximate Price: $1,472

THINGS DIDN'T START OFF PEACHY, as our case and CPU jumped up in price. We put further strain on our budget by going with a more expensive (by $10) mobo. We went with the Asus board because of the solid build and clear indication that it supported both PCIe and SATA modes for its M.2 slot. Some boards support M.2 in PCIe AHCI only. (This can be confusing as the SATA bus can operate in AHCI or RAID modes, so terminology overlaps.) If you buy a SATA-mode M.2 SSD like the 850 Evo we love, the BIOS just won't see it.

To make up the difference in price, we went with XFX's R9 390 over the Asus Strix model. The XFX GPU is clocked at 1,015MHz compared to the Strix's 1,090—only a 6.9 percent drop in clock speed.

We also saved money on memory. We went with a 2x 8GB kit over 4x 4GB, saving a significant amount of money. The speed difference is minimal, and with fewer modules, there are fewer points of failure.

TURBO

THIS TURBO RIG remained mostly the same as the build from last month, with one major upgrade: We went from the SATA Samsung 850 Evo M.2 to the NVMe 950 Pro M.2. That's no small upgrade, and one that doubled the cost of the SSD.

We were able to make this upgrade for a few reasons. First of all, the price of the Core i7-5820K fell to $350 from $385. That $35 change represents a 9.1 percent fall in price, which is a big plus for system builders who want the cores offered by Haswell-E. As it turns out, the quad-core Core i7-6700K Skylake is $14 more than the Haswell-E. If raw clock speed isn't your biggest consideration, this gives builders some motivation to go with Haswell-E over a Core i7 Skylake system.

We also saved some money by going with an 850W PSU. While we like the power offered by a 1kW PSU, 850W is more than enough for most, and even allows some headroom for overclocking. Small drops in the prices of the Corsair water-cooler and the WD Black HDD helped as well.

We did spend $10 more for our RAM, snapping up a set of red Corsair Vengeance LPX sticks to match our MSI motherboard's color scheme.

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

INGREDIENTS

PART			PRICE
Case	Cooler Master MasterCase 5		$107
PSU	EVGA SuperNOVA G2 850W	NEW	$123
Mobo	MSI X99A SLI Plus		$230
CPU	Intel Core i7-5820K		$350
Cooler	Corsair H100i v2		$100
GPU	2x PNY GTX 980Ti (*Reference*)		$1,280
RAM	32GB (4x 8GB) Corsair Vengeance LPX DDR4-2666	NEW	$180
SSD	512GB Samsung 950 Pro M.2 (NVMe)	NEW	$322
HDD	Western Digital Black Series 2TB 7,200rpm		$122
OS	Windows 10 (*Download*)		$110

Approximate Price: $2,924

UPGRADE OF THE MONTH

SEASONIC SNOW SILENT 750W

We've always recommended that builders settle for nothing less than an 80 Plus Gold-rated power supply. Power supplies with a Gold rating usually tend to be of higher quality and sport longer warranties. But if Gold isn't good enough, you can always step up to Platinum.

SeaSonic's Snow Silent PSU has a seven-year warranty, Platinum-rated power efficiency of up to 92 percent, and a low-noise fluid dynamic bearing fan. Sounds good to us.

$155, http://seasonicusa.com

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