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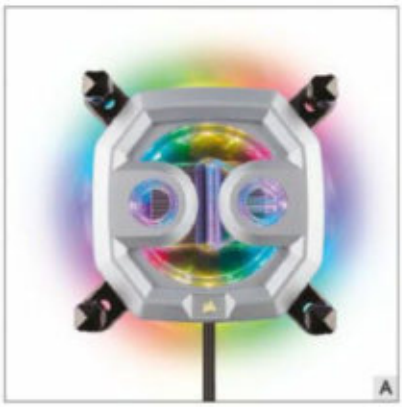
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Next Issue On Sale August 20, 2019

Alan Dexter

TIGHT BUDGETS DEMAND CREATIVITY TO PRODUCE SOMETHING SPECIAL

WE GET TO PLAY with a lot of high-end gear here. Our cupboard is bursting with premium processors, expensive graphics cards, superfast SSDs, feature-rich mobos, and everything else that goes into producing the best machines we can put our minds to. If we need to build a rig for a specific use, we can generally lay our hands on the core components quickly, and piece together a PC that excels at the task at hand.

There's a bit of a disconnect between having all this gear to play with and building in the real world, though, and this is most obvious when we're building to a tight budget. It's rare that we have everything we need for a budget build, for a couple of reasons: Firstly, new tech tends to appear in top-end components initially, and that's the gear that makes it into our labs and cupboards. More budget-oriented hardware tends to come later, and it can be hard getting our hands on it. This is compounded by the fact that when there's less profit to be had, there's a general reluctance to promote the gear.

Which brings us to our cover feature: our $350 kick-ass budget build. When we were working out what we were going to do for this feature, we priced up a number of budget machines, but eased back on the crazy low price points, because we didn't feel that they would produce the kind of performance that we demand. It isn't just about building the cheapest machine you can; it's about checking that "great value" box as well. So, while there are cheaper CPUs, we felt that too many of them were too compromised to be considered. To find out what we did end up building, turn to page 24. The final rig was impressive, and can stand on its own, or form the basis of a more capable system.

There is one element of this build that we always consider far longer than we probably should: the OS. We're mainly about Windows here. We talk about Linux lots, and when it comes to specific tasks, it can often be hard to beat, but for general-purpose computing, our preference is still Windows 10. It's just so easy to use, so predominant, and has so many great tools.

There's just one problem: cost. While you can argue that Windows is great value for money because of how well supported it is, it's difficult for Microsoft to compete with operating systems that cost zilch. Of course, you should donate money when you download Ubuntu or whatever, but you're not forced to, and it makes no difference to the software whether you do or don't. Which means it comes down to $0 versus $100. It's not hard to see which one gets the nod from us; something that is made easier by the fact that the latest versions of Ubuntu are incredibly straightforward to use, even for novices. Still, if you can afford an extra $100, upgrading to Windows 10 makes sense. Enjoy the issue.

Alan Dexter is Maximum PC's *executive editor and a punisher of hardware. He's been a tech journalist for over 20 years, and has no problem upsetting the PC industry as a whole.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

AMD Steals the Show at Computex

The red team launches new CPUs and GPUs

IF IT BELONGED to anybody, Computex 2019 was AMD's. It picked the event to launch its new 7nm Zen 2 Ryzen 3000 series processors and the first Navi graphics cards. Zen 2 is no surprise—we've been drip-fed details for months—what we do have now are the hard numbers for the initial release. The five new chips range run from a $199 Ryzen 3 3600 through to a 12-core Ryzen 9 3900X for $499. Clock speeds don't vary much, with 300MHz between the fastest and slowest base clocks, and 400MHz on the boost clocks. We can't expect miracles—as the die process shrinks, you have to lower voltages, which makes it harder to run really high frequencies. Chips are struggling to reach 5GHz; it's as much about efficiency and core count. The thermal performance is notable: The eight-core 3700X manages on a thermal design power of just 65W, 30W below a comparable Intel i9-9700K.

Instructions per cycle show an improvement of about 15 percent—handy, rather than dazzling. The original Ryzen managed about 50 percent over the previous Bulldozer family, but that was a huge technology leap, which we won't see for the foreseeable future. The Zen 2 core also introduces us to PCIe 4.0. This is particularly handy for AMD, which uses four PCIe lanes as the internal interconnect between processor and motherboard chipset, a notorious bottleneck, particularly for fast storage. It's not going to make much difference on the graphics card side of things. You'll need new X570 chipset motherboards, though, despite early hopes of backward compatibility.

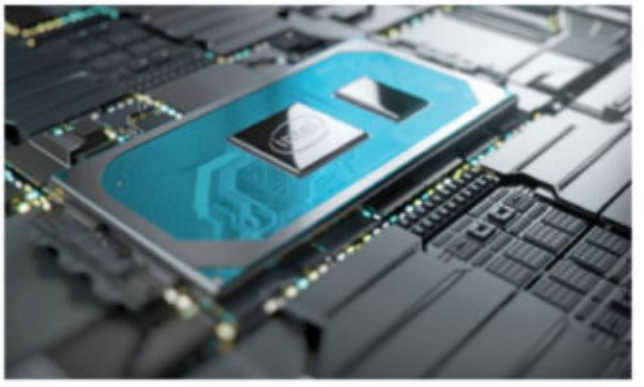
This is a solid step forward for AMD: more efficient, more cores, and particularly strong in performance per watt. Keeping competitive in the world of processors requires investment in depth; you need to be working on the replacement design, and the replacement for the replacement, and already thinking beyond that as you launch a new design. This is where AMD has failed in the past. It never really managed to capitalize quickly enough on its innovations. Zen has changed that. The Ryzen 3000 range should be available now. Zen 2 shifts to servers next, with a new EPYC series before the end of the year. News on Threadripper versions was notable by its absence.

Expect graphics card makers to take Navi further than AMD's initial clock speed pretty soon.

Soon after Computex, AMD added a cherry on the top: the 16-core version. As soon as people saw the first Ryzen 3000 chips, it was clear there was room for two of the Core Complex chiplets, so a 16-core version was inevitable. The Ryzen 9 3950X has a base clock of 3.5GHz and a maximum boost of 4.7GHz. Despite all the horsepower, it manages a TDP of 105W—commendably low. The 16-core beast will be available in September for $749. That last bit is the clincher; to match this performance running Intel, you can double that, and more.

We don't have anything official on performance yet, but engineering samples have been put through their paces. One leak has it pitched against Intel's Core i9-9980XE, $1,999 of 18-core Skylake-X, using the GeekBench benchmark. The 3950X leaps ahead in multicore, and tops the Intel comfortably in single-thread, too. It also trounces AMD's own Threadripper chips. The huge amount of cache helps—the 3950X carries a whopping 72MB of L2 and L3. Others have been playing with overclocking, reaching 5GHz, then breaking world records in GeekBench, Cinebench R15, and R20. Is this the CPU to finally take the crown as the world's fastest gaming chip?

AMD's graphics department has also been busy with its own 7nm silicon: Navi, which also made its debut at Computex 2019. The architecture has the official name of RDNA. The $379 Radeon RX 5700 has 36 compute units, 2,304 stream processors, and carries 8GB of GDDR6 on a 256-bit memory bus. It has a base clock of 1,465MHz, a boost of 1,725MHz, and a game clock of 1,625MHz. This equates to 7.95 Tflops of processing power. Above this is the $449 Radeon RX 5700XT, which has 40 compute units and 2,560 stream units. It runs at a base clock of 1,605MHz, a boost of 1,905MHz, and a game clock of 1,755MHz. It manages 9.75 Tflops. What's a game clock? It's a new metric AMD has coined to indicate a more typical speed used in games. Base and boost clocks



It may be horribly late, and starting life as low-power mobile chips, but Intel's Ice Lake architecture is looking good so far.

The worst kept secret of Zen 2, the 16-core range-topper: a $749 chip that thrashes anything Intel has at twice the money.

are rarely used for any length of time; a card mostly runs somewhere in between, hence game clock.

AMD had the usual bar charts pitching the new cards against rival Nvidia ones in a favorable light. The RX 5700 XT is pitched against a GeForce RTX 2070, and the RX 5700 against a GeForce RTX 2060, over 10 games. The Navi cards win across the board, from a couple of percent to over 20. Noticeably faster games include *Battlefield 5* and *Metro Exodus*. All the tests were run at 1440p, a sweet-spot for Navi no doubt; AMD has called it the best 1440p GPU in its class. Ray tracing? AMD has left that path for Nvidia to walk alone. There are other tricks, though, including Radeon Image Sharpening, which sharpens areas of low contrast, and Anti-Lag, a software tweak that gets the processor to pause for the GPU to update a frame. Both cards look to be competitive mid-range models, where AMD has always been strong.

Computex was busy for AMD, but what was happening at Intel? It also has a new microarchitecture: Sunny Cove. It's set to appear in its Ice Lake chips later this year, but the first chips are all low-power mobile parts. Mainstream desktop parts are still months away. Leaked early benchmarks show an IPC bump of 18 percent or better over Skylake. It has new Gen11 integrated graphics, hardware-accelerated AI, built-in Wi-Fi 6.0, and more. But it leaves an embarrassing gap until the new desktop chips are ready. What we do have is impressive, and about 30 laptops are expected with Ice Lake in time for the holiday.

What can Intel do? It did what it always does: It made a good show of what it had, then released a special-edition fastest-ever chip. We saw the Core i9-9990XE a few months ago; now we have the i9-9900KS, a carefully selected 9900K, overclocked to run at 5GHz on all cores, at all times. Bingo! We have the world's fastest gaming chip. The 9900KS will be available later this year, in limited numbers, and at an as-yet unknown eye-watering price.

The battle between AMD and Intel now enters the next round, and Intel has yet to get up from the initial impact the original Zen made. Zen 2 merely strengthens AMD's position. Its chips offer great value for money, and—bar Intel's "specials"—are every bit as fast. It's not over, and Ice Lake is shaping up nicely, but its development is painfully slow. Computex 2019 belonged to AMD, and it looks like the rest of the year will too. **–CL**

> Intel has yet to get up from the initial impact the original Zen made.

THIRD-GEN AMD RYZEN DESKTOP PROCESSOR LINEUP AND AVAILABILITY

	RYZEN 9 3950X	RYZEN 9 3900X	RYZEN 7 3800X	RYZEN 7 3700X	RYZEN 5 3600X	RYZEN 5 3600
Cores	16	12	8	8	6	6
Threads	32	24	16	16	12	12
TDP (Watts)	105	105	105	65	95	65
Base Frequency (GHz)	3.5	3.8	3.9	3.6	3.8	3.6
Boost Frequency (GHz)	4.7	4.6	4.5	4.4	4.4	4.2
Total Cache (MB)	72	70	36	36	35	35
PCIe 4.0 Lanes (CPU + X570)	40	40	40	40	40	40
Thermal Solutions	Wraith Prism RGB	Wraith Prism RGB	Wraith Prism RGB	Wraith Prism RGB	Wraith Spire	Wraith Stealth
Expected Retail Price (USD)	$749	$499	$399	$329	$249	$199
Expected Availability	September, 2019	July 7, 2019	July 7, 2019	July 7, 2019	July 7, 2019	July 7, 2019

XBOX AND PS5 NEXT HOLIDAY

Both pick AMD innards

THE NEXT ROUND of console wars is shaping up. Both sides are circling each other, letting out teasers while we wait for the fight to start. In the red corner we have Microsoft's Project Scarlet (still no idea of the final name). At E3, Microsoft released a few details, along with a slick promotional video. It'll arrive for holiday 2020—that'll be November, something of a tradition for console launches. Hardware includes SSD storage (said to be up to 40 times faster than HDD), coupled to an eight-core Ryzen 3000 Zen 2 processor and Navi GPU. It'll support ray tracing, and will stretch to running at 120fps and 8K. Whilst technically possible, this is an ambitious target for practical use. We don't expect it to do both at once, or to run top-tier titles at anything like this big or fast; 60fps and 4K is more realistic. Project Scarlet is going to be a powerful box, and it has to be—there's no replacement planned for three years at least. The launch of the Xbox One famously fell flat, with much talk about everything except gaming. Lesson learned, the E3 video put enthusiastic games developers front and center. The cost? Rumors only: Smart money is on $499, with an outside chance of $449, although this has to be near break-even on the production costs.

In the blue corner we have Sony's PS5, and the specs sound similar: SSD storage, AMD silicon, ray tracing, and 8K support. Launch and price to be confirmed, but both are going to be close to the Xbox. Sony has traditionally been the more affordable option; the high cost was seen as a barrier for the Xbox One, which was $100 more than the PS4. Given the expensive innards, it looks unlikely that Sony can repeat that trick. Spec-wise, the machines look similar, but it's games that sell consoles, not teraflops. Like previous console wars, it looks likely to be about which has the best games, which could mean you need both if you want play every top title. **–CL**

FACEBOOK MONEY

NEW DIGITAL CURRENCY DUE NEXT YEAR

FACEBOOK HAS LIFTED THE LID on its forthcoming blockchain currency, Libra. This isn't a bitcoin rival; it's pegged to the value of real assets, a basket of stable currencies, so its value won't jump around alarmingly. Unlike typical blockchain "coins," it will be tightly controlled, too. It's not really a cryptocurrency, but international online money. Wallets are integrated into Facebook apps, and you can exchange money from within them. Don't panic, though: It won't be controlled by Facebook, but by a separate association, along with 27 other partners, including Visa and Uber. The fees are said to be "minimal," and interest will be earned on any holdings. A major target is the millions of people around the world without access to banks, but with smartphones, which is a big market.

Facebook has created a subsidiary called Calibra to manage Libra within the Facebook empire, so your financial dealings won't be mixed in with the rest of your data, which is good news. It should be as secure and private as any blockchain currency. **–CL**

ITUNES FINALLY CRASHES OUT

Rip, mix, burn

THIS FALL'S UPDATE of the Mac OS, 10.15 Catalina, will see the end of iTunes, sort of. Its functions will be split across Apple Music, Apple Podcasts, and Apple TV. Anything you've bought will appear in one of those; your music and playlists are safe. Finder will take over the job of synchronizing mobile devices. It isn't dead yet, though—the Windows version will live on. It has to, as not every iPhone user has a Mac. Why is this happening? Well, it had become a bloated mess, with too many functions, and endless updates. Legal issues over licenses added annoying DRM, too. Few are going to mourn its passing. iTunes arrived in 2001, and introduced purchases in 2003. It, and services like it, helped kill the CD market. From a high of 943m annual sales at the turn of the century, sales slipped to 52m last year. Apple saw the future, but not far enough ahead, it seems. Streaming and the cloud are where the action is. If anything killed iTunes, it was Spotify, a victory for the subscription model over ownership. That's where Apple needs to head. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

HARD DRIVES NOT DEAD
Seagate has revealed the biggest HDDs yet, the 16TB IronWolf and Exos, which use a laser; prices from $610. 20TB due next year.

PHOTONIC AI CHIPS
Researchers have built an artificial neurosynaptic network. Just four neurons, but 1,000 times faster than the real thing.

CLASSIC GAME GETS RTX
Nvidia has refreshed the 22-year-old *Quake II* with the full ray-tracing treatment.

TRAGEDIES

BLUEKEEP PATCH
Microsoft has patched Win XP in an effort combat the BlueKeep vulnerability, which can enable nasty ransomware attacks.

KEEP IT SIMPLE
After spending over $10,000 on MacBook Pro screen repairs, an engineer realized the brightness was just right down.

AI STILL NEEDS US
Real people handle about 15 percent of calls that Google's Duplex can't manage to parse.

Stadia Due This Fall

THE GAMES INDUSTRY is about to get a good shaking: Google's Stadia game streaming service is due to go live in November. Stadia Pro at $9.99 a month gives access to the full library of games, while a special Founders Package at $129.99 gives you three months' subscription, a Stadia controller, and a Chromecast Ultra. Sometime next year there will be a free version, called Stadia Base. This will limit you to running games at 1080p, and you don't get your pick from the library, although you can buy individual titles. The launch games list is short—just 32, with no exclusives—but they are all top titles *(Balder's Gate III* anyone?), and there are a lot more in the pipeline.

The exact resolutions you'll be able to use effectively will depend on the speed of your Internet connection. Google says you'll need 10Mb/s for 720p, double that for 1080p, and 35Mb/s for 4K. If you have a data cap, you could be in trouble, too. You also need low latency; critical for gaming, and doubly critical for multiplayer games.

Stadia's rival, Microsoft's xCloud, is also due a public trial. The difference is that Stadia offers more than running a game on the cloud; it's a development platform, too. xCloud is, put crudely, a rack of console motherboards playing games; we haven't really left the Xbox environment. Google's Stadia is more ambitious—a developer could potentially make just one version of its game that'll run pretty much anywhere with a decent broadband connection at 4K. Potentially, Stadia could kill not only the idea of owning games, but owning the means to run them independently, too. **–CL**

***Tom Clancy's Ghost Recon Breakpoint*, one of Stadia's initial lineup, looking good.**

Are You Ready for PCIe 5.0?

We haven't got PCIe 4.0 going yet, and already the official specs for PCIe 5.0 have been released. Speeds are set to double from 16GT/s to 32GT/s per lane. PCIe 4.0 was announced in 2011, but graphics cards didn't need it. They rarely hit the buffers when running on an eight-lane PCIe 3.0 slot, let alone a 16-lane slot. PCIe 4.0 enables you to use fewer lanes on some peripherals, dropping the graphics card to a four-lane connection for example. It also helps AMD as it uses PCIe lanes as the processor chipset interconnect. Cheap, fast SSDs change all that. A four-lane M.2 board needs all the bandwidth it can get. Storage demands may prompt a fast adoption of PCIe 5.0.

Xbox Game Pass Comes to PC

Microsoft's Xbox Game Pass for PC will run in beta at first, at $4.99 a month, then will jump to $9.99 a month. There's a healthy library of over 100 titles, and it should grow fairly quickly. The Xbox console version of Game Pass (they have exactly the same name, which could get confusing) has over 200 titles, although a good few of those are getting old. It's a good deal for PC gamers, as you get to pick your games and play them online with your buddies; console gamers have to part with $14.99 a month for Xbox Live Gold to do that. It also gives you a 20 percent discount on games, and 10 percent on add-ons. Microsoft describes the Xbox Game Pass as a "Netflix-style subscription service."

HUAWEI

GOOGLE AND ARM DROP HUAWEI

Chinese firm is shunned

WHATEVER YOU MAKE of the politics behind the US-China tussle, the ramifications are getting serious. A slew of big companies have been obliged to stop doing business with Huawei, including Intel, Qualcomm, Broadcom, and Google. No Google means no Android OS. The bulk of Android may be open source, but crucial parts of it—the Play Store, Gmail, location services, and more—aren't. Huawei has been working on its own OS since 2012; according to sources inside China, it could be out by this fall. It will be compatible with Android, although recompiling apps makes them considerably faster. The Chinese market is huge, and difficult to break into. Google won't want to be left out for too long, or it may find it hard to get back. The company is in talks with the US government to try to get an exemption from the ban.

Huawei may be able to live without Google's Android, but it has also lost access to ARM, and replacing the silicon isn't going to be so easy. Chips using licensed ARM technology run on about 95 percent of the world's smartphones. Alternative designs are thin on the ground—a couple of open-source projects (MIPS and RISC-V), and little else. Huawei owns HiSilicon, which makes Kirin SoCs (based on ARM designs), but starting from scratch on new designs would take years. Before the ban started, Huawei stockpiled enough chips for over three months. When this pile runs dry, it'll be in trouble.

Where does all this leave owners of Huawei phones? Thankfully, you'll be fine. All the bans only apply to new devices. What happens if the situation hasn't been resolved before the release of Android Q isn't clear. For now, the advice has to be to avoid new Huawei phones until the situation settles down again. **–CL**

Jarred Walton

TECH TALK

AMD Reveals Navi and Its RDNA Architecture

AMD'S LAST MAJOR REVAMP of its GPU architecture was in 2012, with the HD 7970 and related first-gen GCN graphics cards. Everything since then, up through the Vega 20 GPU at the heart of the Radeon VII, has used a variation of GCN. At E3, and with the official unveiling of the Radeon RX 5700 XT, AMD finally gave us the skinny on its plans for the next generation of GPUs, code-named Navi, and using a new RDNA architecture.

Perhaps the biggest change from GCN is that AMD has reworked the way instructions are grouped. In GCN, AMD used a Wave64 work-item that combined work for 64 GPU threads. Each Wave64 would end up being split into four chunks of work that would be sent to a SIMD16 structure, requiring four cycles to execute the work-item. If the Wave64 didn't fully utilize 64 threads, no matter: It still took four cycles. A shared scalar unit would handle interleaving the workload on to the SIMD unit.

For RDNA, AMD GPUs now have a base Wave32 work-item, and it feeds into a SIMD32 vector unit. There are also two scalar units for scheduling the workloads, which increases throughput to one Wave32 per cycle. Not only do heavy workloads end up executing faster, but lighter workloads—where only 16 threads of work are needed, for example—now complete in one cycle instead of four. Basically, everything becomes more efficient.

AMD also adds a new L1 cache to the GPU caching hierarchy, joining the existing L0 and L2 caches, and RDNA features dual compute units with some shared resources to keep things plugging along—AMD calls this a Workgroup Processor. Wider data paths connect the pieces together, and the full graphics pipeline can now work directly with compressed color data.

The net benefit is that RDNA should deliver roughly 25 percent better performance per clock—or IPC (instructions per clock). And while I haven't been able to run benchmarks yet, AMD claims the 9.75 Tflops RX 5700 XT should perform slightly better than the 12.67 Tflops RX Vega 64. It also manages this with 40 CUs compared to Vega's 64 CUs. But it's not just about raw performance. The RX 5700 XT will also have a TBP (typical board power) of 225W, compared to Vega 64's 295W.

Navi makes some sweeping changes, but will they be enough?

That's an excellent improvement if true, and AMD says performance per watt is 50 percent better than the last-gen GCN architecture. It needs to be a major improvement, as Nvidia has been killing AMD on GPU efficiency for seven years.

What's alarming is that RDNA appears to continue a lot of the GCN legacy. Navi is manufactured at 7nm, yet performance and efficiency look to be at the same level as Nvidia's three-year-old 16nm Pascal architecture. The RX 5700 should equal the performance of Nvidia's RTX 2070, but without any ray tracing or deep learning enhancements. (Ray tracing will come in next year's Navi 20 and RDNA 2.) It looks like Pascal rather than Turing. And the 12nm RTX 2070 is a 175W TBP part, while the 5700 XT is 225W TBP.

RDNA and Navi are moving in the right direction, but Nvidia has a response—it will be launching the RTX 2060 Super and RTX 2070 Super (and later the 2080 Super). Performance should be up to 25 percent faster than existing cards, so the target AMD was aiming for has moved. I'll look at new GPUs from both companies next month.

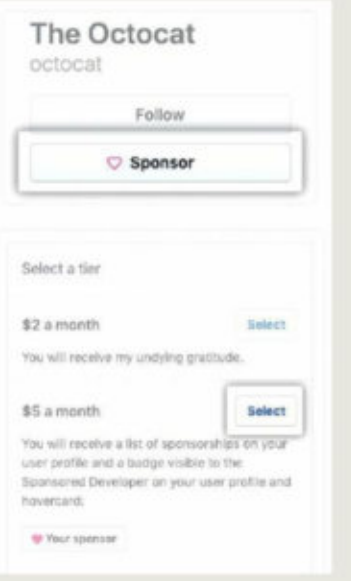
Jarred Walton has been a PC and gaming enthusiast for over 30 years.

Alex Campbell

OPEN SOURCE

It's Now Easier to Buy a Dev a Beer

GITHUB SPONSORS has made it easy to support the developers of open source who host code on GitHub. The program aims to make it easier for people to contribute dollars, if they aren't able to contribute code. The big question is, who will be willing put up cash for work that they've enjoyed for free?



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As the saying goes, free software is free as in speech, not beer. Beer is not free. Neither is rent, nor electricity. Yet these three things—beer, rent, and electrons—are just some things an aspiring developer might have to consider when giving up hours to build things for the benefit of strangers.

If you're not someone who busies themselves writing code or documentation for fun, it can be hard to figure out how to contribute to open-source projects. You may really love an application or need a piece of code, but there is often little most people can contribute easily. Not everyone can write code. Not everyone knows enough about how a software package works to contribute documentation. Just like the Médecins Sans Frontières (Doctors Without Borders), not everyone can be (or wants to be) a doctor or nurse. But many people can contribute a little spare cash, even if it's just once.

Previously, people who wrote software would have a hopeful PayPal button on their blog, in hopes that someone could show their appreciation for the hours logged at a keyboard. Being compensated for time and effort spent on developing something you give away for free is hardly an easy thing to do.

Many open-source projects are designed and built by people who may not receive a shiny nickel for their work. Bloggers and content creators embraced platforms such as Patreon to fund their ability to continue creating art and content. GitHub Sponsors looks and feels quite similar, though students, hobbyists, or budding small business owners who write code are the prime beneficiaries. A developer who wants to be sponsored by the community is able to create a GitHub Sponsors profile outlining donation levels, and offer small thank-you gifts.

> This new program will be a test to see how generous users of open source really are.

I like this move, though I am forced to wonder just how effective it might be. The new program does have some immediate benefits. First off, developers wanting to solicit donations in order to support their ability to continue creating software won't have to build a third-party platform or ask people donate to their PayPal account. That said, many people see "free software" as free (as in beer). While low or no-cost software is a perk, the idea of free and open-source software is that at some point, the users of the software contribute in some way to the improvement of the software. Sometimes, that means filing a bug report. Sometimes, it means translating an interface to another language. Sometimes, it means putting a couple bucks in the hat to help keep the lights on. From my own limited experience, offering up a few dollars to help out a project has been the exception rather than the rule. For myself, I can count on one hand how many times I've made direct donations. I hope greasing the skids to making a donation will make it more likely for people to do so. In a way, this new program will be a test to see how generous users of open source really are.

For now, GitHub Sponsors is rolling out slowly, and if you are a developer, you can get on a waiting list to put out the digital tip jar. If you want to help out a developer by buying them a beer (or coffee), the feature is available now. As of writing, GitHub is making sure 100 percent of donations goes to developers. (Well, user accounts who you can donate to—they don't have to be a "developer.") GitHub is also matching all donations up to a maximum of $5,000 per recipient for the first year. Like those NPR challenge grants, your five bucks can be 10 for the first 12 months.

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

THE LIST

THE BEST GEAR FROM COMPUTEX 2019

8 COOLER MASTER MASTERLIQUID DUAL PUMP AIO

It's good to challenge the norm, and Cooler Master is definitely doing that with this chunky cooler.

4 ASUS ZENBOOK DUO

You know what laptops need? Two screens. Luckily, Asus has your back, with this funky game-changer.

7 RAZER BLADE STUDIO EDITION

We're suckers for svelte power, and when these drop in the fall, we'll be eager to get our hands on them.

3 CORSAIR MP600 M.2 SSD

Offering read speeds of 4,950MB/s, this PCIe 4.0-ready SSD has us excited about where storage could go next.

6 CORSAIR HYDRO X

Corsair is shaking up the water-cooling world with its Hydro X branding, and the possibilities are certainly intriguing.

2 AMD RADEON RX 5700

Navi, Vega's highly anticipated follow-up, may not look like much, but should bring the battle back to Nvidia.

5 10TH-GEN INTEL CORE PROCESSORS

Previously known as Ice Lake, these 10nm laptop chips offer improved integrated graphics and AI support.

1 AMD RYZEN 9 3900X

There's no doubt that Zen 2 was the star of this year's Computex. This $499 12-core model looks stunning.

HEAD TO

BY CHRISTIAN GUYTON

GTX 1060 6GB vs. GTX 1660 6GB vs. RX 590 8GB

There's plenty to choose from right now in the world of gaming GPUs. With Nvidia recently releasing the GeForce GTX 1660 series, choosing a card for 1080p gaming is a challenge. So, we kind souls at *Maximum PC* have nailed down the three best 1080p cards currently available—the new GTX 1660 6GB, the older GTX 1060 6GB, and AMD's Radeon RX 590 8GB—and we're going to throw them into a cage and see which is the last one standing. What? That's GPU cruelty? OK, we'll just break down their pros and cons instead....

ROUND 1

Value

At a first cursory glance, the GeForce GTX 1060 is the victor here. It's the cheapest card of the three, after all, costing $200 on average, although the Radeon RX 590, at around $230, is extremely close. Looking at price-per-gigabyte, the RX 590 beats out both the other cards, packing 8GB of GDDR5 memory against the 6GB offered by the other pair. That extra graphical memory puts the Radeon card in good stead, too—despite being older, the 590 can hold its own, with performance on par with the GTX 1660, even at 1440p ultra.

The GTX 1660 might be the newest of the three GPUs here, but prices have dropped quickly—you should be able to snap one up for only a little more than the RX 590. As you might expect, the GTX 1660 is great value when it comes to baseline performance, although the memory speed isn't any faster than that of the RX 590. Given the minimal price variation, our recommendation for value has to go to the RX 590. The GTX 1060 is too old to justify its price point, while the 590 is a solid card that slightly undercuts the 1660 on cost. As an added bonus, the RX 590 boasts some excellent game bundles—at the time of writing, you could get *Division 2* and *World War Z* for free with the majority of RX 500 series cards.

Winner: RX 590

ROUND 2

Efficiency

Sorry AMD, but Radeon ain't winning this one. The RX 590 is a good card, but it demands 175W of power without overclocking; almost a third more than the 120W required by each GTX card. The system power draw if you attempt to properly overclock is nightmarish, too, the GPU demanding as much as half of the build's entire power budget. Swapping from Nvidia to AMD can often force a PSU upgrade. It's not particularly quiet, either, though this depends on the specific model you purchase. It's worth noting that if you choose to cool your GPU with liquid, noise ceases to be a factor, of course.

The GTX 1660 feels like a clear winner in the efficiency stakes, though. In terms of what it demands from your system, it's near-identical to the 1060, but it simply pumps out superior performance, typically running at around 10–12 percent faster than the 1060, without any significant increase in noise or running temperature. Certain versions of the card perform more efficiently and quietly, too, thanks to manufacturers' proprietary fan technology. That's not to say the GTX 1060 is a slouch in this department, though; most models run very quietly and draw a sensible amount of power—it simply can't quite keep up with its newer descendant.

Winner: GTX 1660

ROUND 3

Overclocking

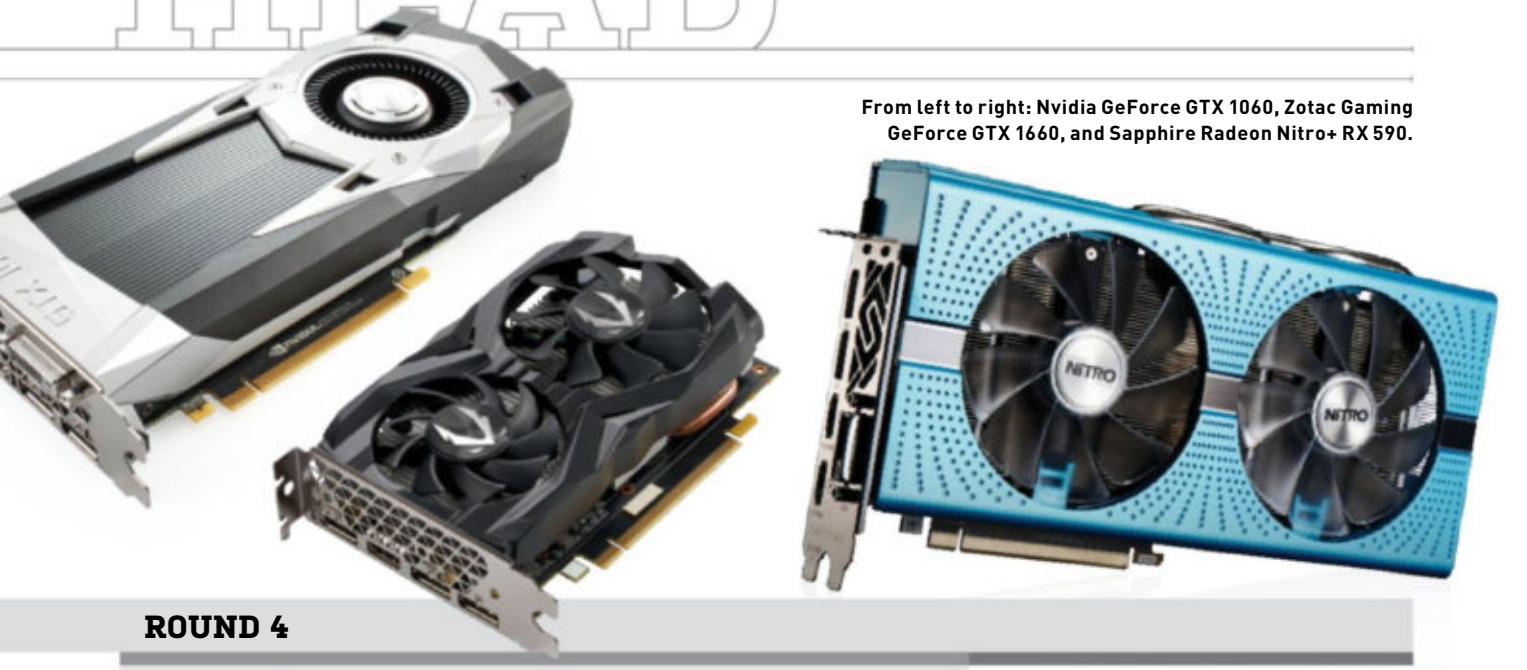
Looking purely at factory boost clocks, the GTX 1660 powers through here. With a boost clock of 1,785MHz against a 1,530MHz base clock, it boasts both the highest maximum speed and the greatest percentage increase from base to boost out of all three cards. The RX 590 struggles with overclocking; even when it was originally released, it ran on two-year-old architecture, so it won't hit any higher than 1,700MHz, even with some serious tweaking. This is perhaps unsurprising to those in the know—the RX 570 and 580 also struggle with overclocking, which results in high temperatures with minimal speed gains.

The 1060 can perform almost as well as the 1660, however, despite its age. It's relatively impressive, with a factory boost clock just barely over 1,700MHz. It still comfortably beats out the RX 590—manual overclocking should easily throw at least another 100MHz on top, too.

When it comes to memory speed, the 590 performs better, capable of hitting 9GT/s (a similar figure to the 1660). The 1660 simply dominates when you commit to proper overclocking. If we dive under the hood, there's simply greater capacity to push the limits of the 1660's hardware. Maxing out fan speeds and heat limits let this card crack 2,000MHz—impressive, given that it still uses GDDR5.

Winner: GTX 1660

HEAD



From left to right: Nvidia GeForce GTX 1060, Zotac Gaming GeForce GTX 1660, and Sapphire Radeon Nitro+ RX 590.

ROUND 4

Performance

On average, the GTX 1660 is the best card here, but only by a small margin. Unsurprisingly, the 1060 doesn't perform too well, but it does the job. Performance across our benchmark games is very varied. The RX 590 dominates in some games, but lags behind both GTX cards in others. This is primarily due to AMD or Nvidia preference from developers in game design, and shouldn't really be a factor when deciding on a card—unless you plan to only ever play one or two games.

The GTX 1060 lags behind in this department due to its age, although the RX 590 puts out reliable figures despite its two-year-old architecture. Broadly speaking, in games where the 1600 boasts higher fps figures, the 590 only narrowly loses out. Both are capable of hitting 60fps at 1440p, too, if you're willing to lower the graphical settings.

Variation between average fps and minimum fps (in the 97th percentile) differs between the cards, too. The 1660 varies by 47 percent on average, while the 590 only varies by 39 percent, and the 1060 by 37 percent, making them both more stable than the 1660. This could be written off as driver maturity, however; the 1660 will likely perform within tighter parameters once it's been around for a while. Overall, we have to give it to the newer card.

	GTX 1660 6GB	GTX 1060 6GB	RX 590 8GB
Tom Clancy's The Division 2 (Avg/Min fps)	62/42	57/45	**69/53**
Deux Ex: Mankind Divided (Avg/Min fps)	55/43	47/37	**56/45**
Far Cry 5 (Avg/Min fps)	**82**/62	71/60	80/**70**
Grand Theft Auto 5 (Avg/Min fps)	**64**/40	57/**42**	50/37
Middle Earth: Shadow of War (Avg/Min fps)	**61/41**	52/36	58/37
Metro Exodus (Avg/Min fps)	**46/26**	40/22	44/24
Total War: Warhammer II (Avg/Min fps)	**65/49**	60/48	56/44

Best scores are in bold. Our test bed consists of an Intel Core i7-7800K, 16GB of G.Skill DDR4-3200, a Gigabyte Z370 Aorus Gaming 7, and a 1TB Samsung 970 Evo M.2. All games are tested at their highest graphical profile with AA turned on at 1080p. Figures provided are an average and a minimum (97th percentile) respectively.

Winner: GTX 1660

And the Winner Is...

The numbers don't lie: Right now, the GeForce GTX 1660 rules the roost when it comes to 1080p gaming. Were it not for the price drops on Nvidia's cards, though, we'd really consider giving it to the RX 590. It's a solid all-arounder of a GPU, with a reasonable price point. If you want to go with Radeon right now, it's definitely the card we'd recommend for 1080p gaming. We can't really find it in our hearts to recommend the poor GTX 1060, though—it's a good unit, and if you're already rocking one, there's no real need to upgrade just yet, but it can't compete with the current generation of $200 cards.

The 1660 isn't a mind-blowing card by any means, but if you're looking for mid-range gaming that won't hurt your wallet, it's the best option right now. If you're using anything older than a 970, it's an excellent choice of upgrade. However, with the first Navi cards closer than we thought, it might be best to weather the storm for a few more months to see what AMD will bring to the table. At this point, we wouldn't even rule out seeing something like a Radeon 5600 in the not-to-distant future. So, the 1660 wins—but watch this space, folks.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Win 10 Upgrades
> Video Editing
> External Drives

USB Won't Act Right

Dear Doctor, I'm hoping you can help me with a problem that's been plaguing me for the last year: My USB ports can't all be used at the same time. I'm only using a keyboard (two ports), a mouse (one port), and a Logitech C920 webcam (one port). They all plug into an Asus Sabertooth X99 motherboard, with a Core i7-5930K, and 32GB of Corsair RAM. I have to frequently switch the mouse (a Corsair Ironclaw) between USB ports for it to be recognized. This wouldn't be an issue if I didn't have to run Linux so often for my job. When I use Windows or Linux exclusively, there is no problem. All my drivers are current and I'm using the latest version of Windows 10.

I'm also running two GeForce GTX 980 Ti graphics cards, a Samsung 950 Pro NVMe SSD for the boot drive, and a 3TB Western Digital HDD. Before buying new games, how can I tell if they'll recognize both of my GPUs? **–PapaHomey**

THE DOCTOR RESPONDS:
Asus's Sabertooth X99 is loaded down with lots of USB connectivity, including four USB 3.1 Gen 1 ports, four USB 2.0 ports, and two USB 3.1 Gen 2 ports on its back panel. Try plugging all your peripherals into the blue USB 3.1 ports and see how they behave.

If the problem persists, and you see it under Windows, try disabling USB selective suspend. This feature allows the OS to put one port to sleep without affecting the others. In Cortana's search box, type "Edit power plan" and hit Enter. Click "Change advanced power settings" and expand the "USB settings" branch. Change "USB selective suspend setting" to "Disabled," then click "OK."

To troubleshoot further, the Doc would need more info. If there is no problem when running Windows or Linux exclusively, when does the issue manifest? Is this a virtualized environment? Is the mouse the only peripheral affected? There may be other variables to isolate still.

As for multi-GPU support, plenty of DirectX 11-based games still benefit from your GeForce GTX 980 Tis in SLI through Nvidia's drivers. Under DirectX 12 renderers, enabling multi-GPU functionality falls on the developers' shoulders. Since two- and three-way configurations represent such a small percentage of gaming PCs, fewer titles receive the requisite work to make SLI function properly. Absent an official list of SLI-enabled games, spend some time with Nvidia's official SLI support community at https://forums.geforce.com/default/board/50/sli/.

Upgrading to Win 10

Hi Doc. As someone who procrastinates, and with the demise of Windows 7, is there still time to upgrade to Win 10? **–Frank Esposito**

THE DOCTOR RESPONDS:
Technically, Microsoft's offer to upgrade to Windows 10 from Win 7 or 8.1 expired in 2016, but the Doc kept hearing that readers with older versions of Windows were still able to install a licensed copy of Windows 10 right up until he received your email. So, he set out to find an old machine in the lab running Windows 7.

After digging in a closet, the Doc found a laptop previously used to log power data. He fired it up, opened Microsoft's "Download Windows 10" page at www.microsoft.com/en-us/software-download/windows10 and hit "Download tool now." When the Media Creation Tool finished downloading, he launched it, and began the Win 10 setup. Given the option to "Upgrade this PC now" and "Create installation media for another PC," he chose the former. After navigating his way through a series of prompts, he emerged with a valid digital license for Windows 10 Home. While there are no guarantees that you'll see the same, at least for now the upgrade does seem to work.

Thanks for reminding the Doc about this one. He's going to spend the weekend digging up aging test machines and wiping them clean with fresh installations of Windows 10.

New Build Dilemma

Hi Doc. I recently built my first PC with a friend. It lives in an NZXT H500i ATX chassis and includes an Asus Prime B450M-A motherboard with an AMD Ryzen 5 2600X. We went with the stock cooler for now. We also used a 250GB Samsung 970 EVO Plus NVMe SSD, a Rosewill HIVE-series 1,000W modular PSU, a Gigabyte GeForce GT 1030 OC 2G, and a single 8GB stick of Corsair Vengeance LPX DDR4-2400.

We mounted everything inside of the case correctly. Then, when we hit the power

↘ submit your questions to: doctor@maximumpc.com

button, the RGB LED strip came on and the fans started spinning, but the system never booted. The monitor just said there was no signal. We even replaced the CPU with an AMD Ryzen 5 2600, and that didn't work either. We also installed an AMD Radeon HD 6450 1GB GDDR3, to see if the graphics card was the problem—no luck. Is there anything you can tell us to help fix this? **–Zack Rogers**

THE DOCTOR RESPONDS: The Prime B450M-A doesn't come with Asus's Q-Code diagnostic LED read-out, which would help you pinpoint where the boot process is freezing, but it sounds like you're well on your way to troubleshooting the issue.

Having tried two CPUs (both of which show up on Asus's supported list since the motherboard's first BIOS release) and a second graphics card, verify that your DDR4 DIMM is in the DIMM_A1 slot. If it is, pop it out and reseat it. Also, bear in mind that both Ryzen CPUs you tried come with dual-channel memory controllers. Using just one module leaves half of that controller unutilized. Consider a second, matching DIMM for better performance.

If you still can't get the PC to boot, check that the 24-pin ATX and eight-pin EATX +12V connectors are plugged in securely. The next step would be to disconnect the power, pop out the CR2032 coin cell battery, wait a couple of minutes, drop it back in, and boot again. If nothing changes, a damaged motherboard might be the culprit.

Accelerating Editing

Hi Doc, I do a lot of video editing with DaVinci Resolve 16. My Windows 10 PC has a Core i7-4790 (quad-core) running at 3.6GHz, with 16GB of RAM. All of my working storage drives are Samsung SSDs, and my graphics card is a GeForce GTX 1070 8GB.

I shoot 2160p videos with a Sony AX700 to produce 30 to 40-minute YouTube videos in 1080p. When I use DaVinci Fusion effects, the editing visibly slows down, and I must use a proxy mode. In the Cinebench R20 test, my PC scores 1,691, though.

How much more speed can I realize by building a new system using a Ryzen Threadripper CPU or an Intel Xeon? Are those my only choices? I looked at HP's Z8 and it's too expensive. Would a gaming system be what I am looking for? Should I just wait for the next Ryzen chips this summer? I hope to keep the cost around $2,500.

–Lee Reichel

Despite its age, the Sabertooth X99 motherboard has enough USB connectivity to support lots of devices at once without conflicts.

THE DOCTOR RESPONDS: According to Blackmagic Design's configuration guide, DaVinci Resolve does all its effects work on your graphics card, while the host processor is responsible for I/O and video compression/decompression. That's important to know for guiding upgrade decisions.

Your PC isn't slow. In fact, the Doc only recently upgraded from a similar quad-core CPU that was ample for his desktop workstation. But four Hyper-Threaded cores and a previous-gen graphics card are almost certainly slowing you down compared to something more modern.

A Ryzen Threadripper is going to give you the most cores for your money. A 16-core/32-thread 2950X would be top of the line. Or you could go with the first-gen 1950X, which also comes with 16 physical cores. Both drop into the Socket TR4 interface found on X399 motherboards.

Upgrading your platform and processor also requires new memory. Threadripper CPUs support four channels of DDR4 at up to 2,933MT/s (in the case of the 2950X). Go with 32GB, at least, across a quad-module kit for the best possible bandwidth.

At this point, your graphics budget is shrinking, but a fast GPU is perhaps the most important part. A GeForce RTX 2080 Ti would take you to the top of what's available, albeit at the greatest expense. A GeForce RTX 2080 would be a better compromise between price and performance.

Plan on spending those savings on a beefy cooler for the Ryzen Threadripper. AMD doesn't include a heatsink or all-in-one with this processor, leaving you to cover the cost. And depending on the capacity of your power supply, it may be necessary to buy something better suited to a high-end rendering workstation. Somewhere in the 750–1,000W range would be apropos.

External Drive Woes

Doc, I've been reading *Maximum PC* for well over a decade. Thanks! Last year, I got a Seagate STEB4000100 4TB desktop drive. I have never been able to get it to work. Disk Management shows it as Drive 3, but the menu selections to do anything besides take it offline are grayed out. Seagate has been totally unhelpful with the warranty and any technical support.

Recently, you published a response to a reader's letter that included using Diskpart to delete the volume and create a new one. I followed your instructions, only to find that Diskpart did not list my drive through the "list volume" command, even though it is shown in Disk Management. I also tried deleting and reinstalling it through Device Manager, with no change in the result.

There doesn't seem to be any way to get this disk working. Do you have another method I can try? Right now, I'm considering using it as a door stop. **–David Winokur**

THE DOCTOR RESPONDS: It could be that the drive is bad right out of the box, David. But before you give up on it, have you tried replicating these symptoms on another machine to rule out the USB connection? Does the "list disk" command in Diskpart fail to show the drive, similar to what you were seeing after typing "list volume?" Have you tried downloading Seagate's SeaTools for Windows utility? The software should be able to identify and diagnose your Expansion Desktop disk.

BUILD A $350 KICK-ASS PC

A nifty rig that won't hurt your wallet

We love gaming at *Maximum PC,* but we have to pull ourselves back from time to time, and remember that some people just want a good, reliable computer to do their work on. Heck, we spend most of our time busily writing away in Google Drive on rigs packing graphics cards worth hundreds if not thousands of dollars. You know, you can build the most powerful PC available, but if you're not going to push the limits of what its hardware is capable of, you're practically washing money down the drain.

With that in mind, we took a look at building a machine that we could use for that thing we all dread: good, honest work. Pre-built systems are popular for simple desktop work—writing, web browsing, and so on—but it's in this area that you may find a good saving can be made. A reasonable desktop system could set you back anywhere between 300 and 600 dollars, were you to saunter down to your local tech hardware store with the intention of leaving with a ready-to-use PC. Sure, building a system takes effort, but if you're a tech-head like us (or you're looking out for a pal who needs a new computer), you know that there's cash to be saved here.

So, we laid out the plans carefully. To keep the price down, we set ourselves a budget of $350. This meant that a CPU with integrated graphics was a must; adding a GPU of any repute would instantly tank our final price. We didn't want this system to be too cheap, though—savings needed to be made elsewhere to ensure that we could secure a decent motherboard and memory. Dual-channel memory was also a must; we didn't want to skimp here. This build needed to be fairly fast, with specs that compared favorably to pre-built systems available for around the same price. Perhaps we'd even get some games running on it, we thought. Perhaps.

Oh, and we're putting Linux on it. That's going to be fun. Some of you reading this might be Linux-savvy, but spoiler alert: We're not. We prefer the warm, familiar embrace of Windows 10 (and we're going to be installing it on this build to run our benchmarking software anyway). But Linux is free, and we do like free things. This could be a tough build to make work, but we're filled with determination. *–CHRISTIAN GUYTON*

INGREDIENTS		STREET PRICE
Case	**Corsair SPEC-05**	**$45**
Motherboard	**ASRock B450M Steel Legend**	**$90**
CPU	**AMD Ryzen 3 2200G**	**$87**
Memory	**8GB** (2x 4GB) **Corsair Vengeance LPX DDR4 3000**	**$50**
PSU	**450W EVGA 450 BT 80+ Bronze**	**$35**
Boot Drive	**120GB Crucial BX500 SSD**	**$20**
Storage Drive	**500GB Toshiba DT01ACA050 HDD**	**$23**
Cooling	**AMD Wraith Stealth**	**$0**
Operating System	**Linux**	**$0**
TOTAL		**$350**

PRICES CORRECT AT TIME OF PRINTING.


AMD
EVGA
450 B
crucial

MOTHERBOARD

ASRock B450M Steel Legend /$90

We reckon we might have been able to track down a slightly cheaper mobo than this, but we like the Steel Legend from ASRock. Not just because it sounds like a really cool spaceship, either. This board comfortably accommodates all the components we're using, and most importantly, it comes with its own DisplayPort 1.2 and HDMI outputs. It's easy to find cheap motherboards at the moment, but be wary—many are older models that are missing new DisplayPorts, instead using the outdated VGA or DVI-I connectors. The Steel Legend also packs seven USB ports, five audio ports, and—most interestingly—a USB-C port, perfect for connecting with newer, flashier hardware.

RAM

Corsair Vengeance LPX 8GB (2x 4GB) DDR4 3000 /$50

It's not the fastest RAM in the west, but Corsair's Vengeance line is a solid choice. We're not limiting ourselves to single-channel memory, despite our budget, opting for two 4GB sticks at 3,000MHz. This ought to be enough to handle whatever light work we throw at it, even with multiple tabs open in Chrome or other memory-guzzling programs. The higher frequency will benefit our processor more than if we were using an Intel CPU, too, letting us squeeze an extra few percent of performance out of it.

CPU COOLER

AMD Wraith Stealth /$0

Ah, the Wraith series. AMD's stock coolers for Ryzen processors are a lot more effective than the vast majority available (looking at you, "near-silent" stock Athlon cooler). While the Stealth might be the ugly duckling of the Wraith series—if you can find one cheap on ebay, we recommend a Wraith Prism or Spire RGB—it does the job effectively, and isn't difficult to install, its small profile meaning that it fits in almost any case, and won't get in the way of your DIMM slots.

CPU

AMD Ryzen 3 2200G /$87

We contemplated a few different processors for this build. Intel was obviously a contender here, with the K-series Kaby Lake and Coffee Lake CPUs as distinct possibilities. Integrated graphics were a must, of course, and ultimately we decided on AMD, but then we were left with a dilemma: Use one of the cheaper new-model Athlons, or a G-model Ryzen chip. We eventually plumped for the quad-core Ryzen 3 2200G; perhaps not the cheapest processor we could have chosen, but a high-quality offering that comes packaged with one of AMD's Wraith Stealth coolers.

SSD

Crucial BX500 120GB /$20

This is the cheapest SATA SSD around right now. It's almost ridiculous how affordable the 120GB version of the BX500 is—a mere $20 compared to other similarly sized SSDs from manufacturers such as Samsung, Kingston, and PNY. Sure, the performance isn't going to blow you away, but it's a SATA drive; you shouldn't expect it to. Crucial's SSDs are still pretty competitive when it comes to speed, though—it's no slouch compared to other models. We're using this as our boot drive to install Linux and core programs only, with our chunkier HDD for file storage.

CASE

Corsair SPEC-05 /$45

We stumbled across this case somewhat by accident, but it's actually quite difficult not to recommend; for just $45, this chassis is spacious, straightforward, and easy on the eye. We're just hoping it'll be easy to build in as well. It comes with something of an anomaly: a 120mm Corsair fan made of clear plastic, with a single red LED mounted on the frame. This produces crimson lighting that bleeds through the curved slit in the front of the case—a minimalist effect achieved without the need for additional LED strips or RGB lighting. The case does have a window, so we can show off the innards of this build, too, but sadly the panel is a cheap acrylic rather than tempered glass. Other than that, though, it's a sturdy steel case.

HDD

Toshiba DT01ACA050 500GB /$23

Older HDDs won't set you back much these days, to be frank. Here we've opted for a 500GB drive from Toshiba to stick within our budget, but you'll be able to upgrade to a terabyte or more without breaking the bank. Western Digital and Seagate both offer comparable HDDs, too. This is where we'll be throwing larger files: games, photos, and videos. This drive isn't fancy, but it is substantial and, more importantly, it's cheap.

PSU

450W EVGA 450 BT 80+ Bronze /$35

EVGA makes good power supplies, no argument. The BT is its superior 450W unit—non-modular, but providing everything a low-end build like this requires. EVGA provides solid warranties and customer support, too—one of the reasons sticking to well-known manufacturers is a good call. 450W is more than enough for this build; typically, your GPU draws the most power from the system, and this PC doesn't have one. Even adding a GPU later on wouldn't demand a PSU upgrade, so there's plenty of room to maneuver.

GETTING READY TO BUILD

WE'RE NOT GOING TO LIE: Getting the gear in for this build was something of a mission. You might imagine that cheaper components are easier to get hold of, but manufacturers are always more eager to push their newest, most expensive hardware. Counting the coins with a build like this produces far more of a challenge for us, and in spite of our best efforts, this isn't a truly budget build. A cheaper processor was certainly an option; an Athlon 200GE would likely be the most affordable option, or a Pentium Gold from Intel.

Looking at our budget breakdown, we arguably overspent on our motherboard. The B450M Steel Legend is a great board, but it's the most expensive component in this build; only the 2200G CPU even comes close. In a build like this, there's little need to spend more than 15–20 percent of your budget on your mobo, but we've gone ahead and used more than a quarter of it. Good budget boards can be tough to come by, but if you're patient, and keep and eye on the sales, you should be able to snap up a similar B450M board for around $70.

The most important part of this build—and, indeed, any project with a tight budget—is getting the most out of the money you're spending. The RAM, case, and SSD we're using are all particularly good value; we challenge you to find a nicer case for under $50, and Crucial's BX series is just ridiculously good value. When it comes to elements such as the HDD and PSU, don't be afraid to cannibalize a part from an older build. This rig really isn't remotely demanding, and if you've got an old hard drive lying around, the SPEC-05 can easily accommodate it.

INGREDIENTS

PART		PRICE
Case	**Corsair SPEC-05**	**$45**
Motherboard	**ASRock B450M Steel Legend**	**$90**
CPU	**AMD Ryzen 3 2200G**	**$87**
CPU Cooler	**AMD Wraith Stealth**	**$0**
Memory	**8GB** (2x 4GB) **Corsair Vengeance LPX DDR4 3000**	**$50**
PSU	**450W EVGA 450 BT 80+ Bronze**	**$35**
Boot Drive	**120GB Crucial BX500 SSD**	**$20**
Storage Drive	**500GB Toshiba DT01ACA050 HDD**	**$23**
OS	**Linux**	**$0**
Total		**$350**

PRICES CORRECT AT TIME OF PRINTING.

1 PREP PHASE

GET YOUR WORKSPACE CLEARED and all the tools you need ready. You'll want some sturdy pliers and a Phillips head screwdriver, preferably one with a magnetic tip, to avoid losing the smaller screws inside the case. For the Corsair SPEC-05, you're also going to need a specific Allen wrench, but don't worry—this comes included in the box. Get your components unboxed and ready to go in, checking that everything is in good condition. There are few things worse than unboxing a damaged part midway through a build. Be careful to avoid placing anything atop an antistatic bag, as they are only non-conductive on the inside. When you're ready to go, get the case upright, and pat something metal outside your case to ground yourself and avoid static shocks.

2 TAKE IT APART

AS WITH ANY BUILD, the right way to start is with a full case stripdown. The metal side panel of the SPEC-05 comes off easily with two thumbscrews, but the plastic window panel is secured with four Allen screws. Use the Allen wrench that comes with the case to remove these, then extract the accessory box from within the HDD cage—this holds a few pouches of extra screws that we won't need for this build, but you will want to extract the set that matches the Crucial SSD, and the stand-offs for mounting the motherboard. It also has some handy cable ties. This case comes with one fan at the front, but none at the rear. If you've got a spare 120mm fan, or a few dollars to snag one online, it might be worth fitting one to the rear to pump up the airflow. For this build, though, we're keeping it as basic as possible. The plastic mounts for 3.5-inch drives inside the drive cage can all be removed, too.

3 SHIELDS UP

THE REAR I/O SLOT on the SPEC-05 has an odd metal shaping on one of the long sides, which can make fitting the motherboard's I/O shield a pain. Persevere—carefully!—and you should be able to slot it in place. Once secured, you need to relocate two of the stand-offs, moving them from the holes marked "A" (for ATX) to the holes marked "M" (for micro-ATX). These can be tough to extract, and case purists might turn up their noses, as there's only two holes for the lower side of the mobo if you're using a micro-ATX or Mini-ITX board. This is a bit frustrating, meaning that one corner of the board will be unsecured, but there's nothing to be done about it. Our cooler uses screws rather than a clip, so remove the two brackets either side of the CPU slot, then install the B450M Steel Legend motherboard by fitting it to the central mounting peg, and screwing it down using seven of the screws you put aside.

4 CPU AND RAM INSTALLATION

THE RYZEN 3 2200G uses integrated graphics—Radeon Vega 8, to be precise—so ensuring that the motherboard and CPU function properly together is vital, but we'll get to that later. For now, lift up the retention arm on the CPU socket, fit the processor (being sure to line up the gold triangle on the CPU with the triangle on the corner of the socket), then lower the arm back into place. Next up is the RAM, which is no trouble to install. The Steel Legend only has clips on one side of the DIMM slots, so open them up, and fit your two sticks of Corsair Vengeance LPX memory into the A2 and B2 slots; that's the second and fourth from the processor socket side. You might assume that the correct slots are A1 and B1 (or perhaps A1 and A2), but this board is a tad unusual, and won't give you full performance from your RAM if you don't use the A2 and B2 slots. If you're not sure, check the motherboard manual.

5 COOL-DOWN TIME

NOW IT'S TIME TO INSTALL the cooler. You need some thermal paste (we favor Noctua's NT-H1 compound), and the cooler backplate from the motherboard. The AMD Wraith Stealth that comes with the 2200G is a straightforward affair; apply a pea-shaped drop of thermal paste to the center of the processor, then push the cooler down on top, and screw it in. Make sure that the side of the cooler fan that has the extended plastic segment bearing the AMD logo is on the opposite side to the RAM; otherwise, you may have difficulty fitting it over the sticks. The four screws on the Wraith Stealth are fitted with springs, so you may need to apply some pressure to get them to catch. Screw in two opposite corners first to make the process easier—ensure that all four screws have caught to the backplate, then tighten them fully. Once the cooler is secured, plug it into the CPU fan slot.

6 DRIVE INSTALLATION

THE CRUCIAL BX500 DRIVE can be attached to the rear of the case's central plate, along with one other 2.5-inch SSD, but for simplicity's sake, we're going to put both drives in the drive cage. Fit the SSD to the center of one of the trays, and screw it into place, then fit the Toshiba HDD; just line up the plastic prongs, and slot them into the holes on either side of the drive. You can screw the drive down for extra security, but it is effectively locked in place, so it's not necessary. Make sure the drives are installed the right way around; their power and SATA connectors should be facing the rear of the drive cage. Once both drives are in their trays, return the trays to the cage. We recommend placing the SSD in the top slot, and the HDD in the third slot down, because this makes plugging them in easier later on. Keeping the drives spaced out helps keep their temperatures down, too.

7 POWERING UP

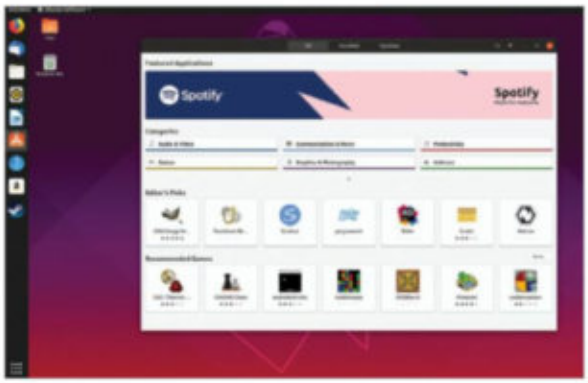
THE LAST THING TO GO IN is the power supply. The EVGA 450 BT is a pretty standard PSU, without modular cabling, so we're going to have some loose cables left over—we'll deal with that in the next step. For now, situate the PSU inside the case, where it sits beneath a metal spur protruding from the mobo plate. Feed the power cables to the motherboard first—the 24-pin main supply and the eight-pin CPU supply, not to be confused with the eight-pin connector for GPUs and other cards. If you're unsure, double-check the side of the connector; the one you're looking for is labeled "CPU." Now take one of the double-connector drive power cables and feed it through to the back of the case, fitting the two L-shaped connectors to the drives. Next, plug the cables from the front I/O and the case fan into the motherboard. These are labeled, but if you're uncertain, consult the manuals.

8 CABLE MANAGEMENT

IT'S TIME TO TIDY the build up. The lack of a PSU shroud for storing loose cables is a shame, but we can make do. We started by separating the power cables we're not using, bundling them at the bottom of the drive cage, then securing them neatly with cable ties. There are clips for securing cable ties on the rear of the motherboard plate, so we'll use these for securing excess cable lengths from the front I/O panel and case fan. The drive connectors and power cables might give you trouble; try to keep as much of the cable length out of sight behind the plate, but there's very little space once the case is reassembled, so don't bunch the cables up. There's not much to be done when it comes to the motherboard power supply cables; feed them through the hole at the bottom of the case and back through closer to their connectors, with the CPU power cable tucked along the top edge of the motherboard.

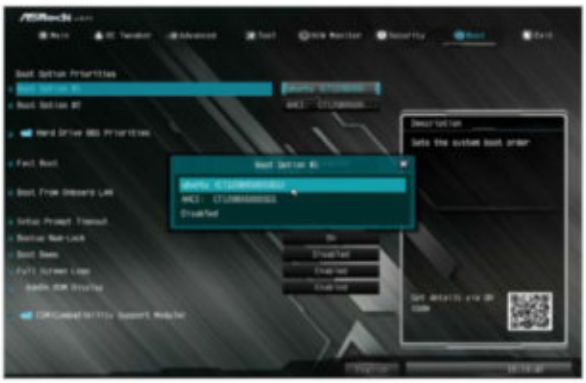
9 INSTALLING LINUX

GETTING LINUX UP AND RUNNING on a fresh build isn't nearly as intimidating as it used to be. Get a blank USB drive and make it bootable; we use Rufus 3.5, although any similar software does the trick. Download the most recent version of Ubuntu Desktop (from http://ubuntu.com), then point Rufus at your USB stick, and select the Ubuntu ISO. Once Rufus is done, plug the drive into the new build, and select the UEFI partition on the USB drive in the boot menu, accessed on this mobo by hitting F11 on boot. You should see several options for launching Ubuntu. You can test it without installing it; it boots from the USB. Ultimately, though, you'll want to install Ubuntu to the SSD; this is fairly straightforward, simply requiring you to follow the steps—just be sure to select the Crucial SSD when it comes to choosing the install drive.



10 BIOS WORK

THERE'S A FAIR BIT TO BE DONE in the BIOS with this build. Mercifully, the Steel Legend's BIOS is pretty easy to navigate. First, ensure the memory is running at full speed, as it may default to 2,400MHz, which impacts the performance of the AMD CPU. Turn on the XMP profile, and change the set frequency from "Auto" to DDR4-3000. You can check that this is working properly by downloading CPU-Z, and checking that each slot is pumping out 1,500MHz; the actual figure is slightly below this, but that's normal. The RAM timings should be correct already, but it doesn't hurt to check. Ensure both drives are being picked up properly, and the SSD is set as the first priority drive when booting, now that you've finished installing Linux from the USB drive. Lastly, you can use the BIOS to adjust the Steel Legend's RGB effects.



1 **The Ryzen 3 2200G runs Radeon Vega 8 integrated graphics, which can handle basic PC work, but is also surprisingly effective when it comes to low-end gaming.**

2 **The Corsair SPEC-05's included case fan is a funky clear plastic number with red LEDs at the corner. It shines through the curved slit at the front of the case, but isn't too impressive unless you're in a darkened room.**

3 **The drive cage has capacity for four drives (either 2.5 or 3.5-inch), although the whole cage has to be removed from the case to access the lowest slot. We're using that space for cable management instead.**

A BUDGET BEAUTY

WE'RE VERY IMPRESSED with this build. The Ryzen 3 2200G's integrated graphics blew us away; sure, it never approached the kind of performance you'd see from a graphics card, but this four-thread processor's Radeon Vega 8 graphics enabled us to get some games running. Our benchmarks at 1080p ultra were unplayable (surprising nobody), but in our preliminary tests in Windows 10, we got *Fortnite* running at 1080p with medium settings, with a smooth 60fps on average. We were even able to get a stable frame rate out of *Apex Legends*, albeit at minimum graphical settings in 720p. Even more bogglingly, we scored the number one spot in three of the four matches we played on this machine. Disclaimer: We are not usually that good.

Despite trying our best to beat the living daylights out of the hardware, the CPU rarely rose above 60 C, even at stress—impressive given that it's only cooled by the stock Wraith Stealth. Benchmarking tests saw the 2200G smash our integrated-graphics Intel Core i3-8100 zero-point in every department. Granted, this build has faster RAM, but as lower speeds have less of an impact on Intel CPUs, it's fair to say that this AMD chip is pulling its weight.

Elsewhere, the Crucial SATA drive did its job well, ensuring relatively speedy boot times. With a slightly larger budget, we might have sprung for a larger SSD; 120GB isn't much, and even with the Toshiba HDD, we're still looking at less than a terabyte of storage. It's hard to argue with the BX500's price, though; you're unlikely to find a cheaper SSD right now, at least not from a manufacturer with Crucial's solid reputation.

We have to recommend the B450M Steel Legend. It's not too expensive and delivers everything we wanted, with ample potential for upgrading, thanks to its two PCIe ports and M.2 drive. It looks a bit absurd (grayscale digital camo and multicolored lighting; do you want to be seen or not?), and the RGB effects aren't going to blow anyone away, but it functions well, fits this build to a T, and has a straightforward BIOS. We found that the EVGA 450 BT remains the "old reliable" of budget PSUs, providing adequate power without too many loose cables, despite its non-modular design.

Linux remains a tricky beast; personally, we'd prefer to stick with Windows for a PC like this, but considering that it comes with a delightful absence of a price tag, the current version of Ubuntu is genuinely great. Compatibility and ease of use have been greatly improved over the last few years. Browsing the Internet and doing basic work is straightforward, and the software center makes getting yourself set up a cinch; we got Steam up and running, and managed to successfully play *Clustertruck*, *Team Fortress 2*, and *Portal* in 1080p at max settings. Overall, we're pleased to report that this build was a triumph.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	541	559 (3%)
CrystalDisk QD32 Sequential Read (MB/s)	540	560 (4%)
CrystalDisk QD32 Sequential Write (MB/s)	372	486 (31%)
Rise of the Tomb Raider (fps)	5	12 (140%)
Total War: Warhammer II (fps)	3	10 (233%)
Tom Clancy's Ghost Recon: Wildlands (Avg fps)	2	10 (400%)
3DMark: Fire Strike (Index)	1,183	2,780 (135%)

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

Our zero-point consists of an Intel Core i3-8100, 8GB of Team Vulcan DDR4 @ 2400, and a 120GB Kingston SSDNow UV400. All tests were performed at 1080p at the highest graphical profile.

3
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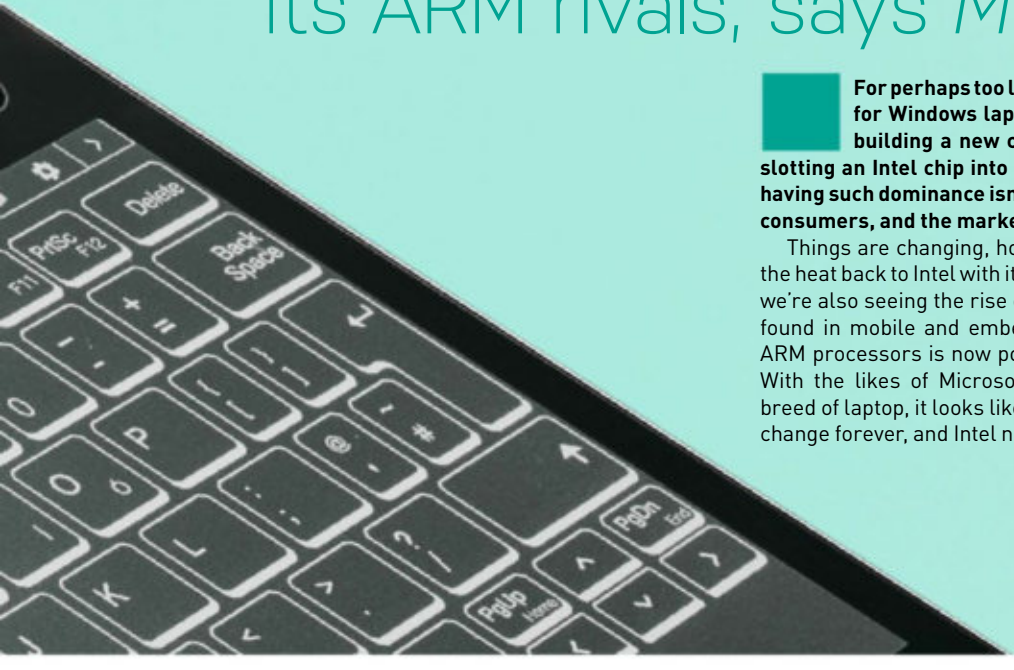
QUALCOMM AND THE RISE OF NON-X86 WINDOWS

Intel is feeling the squeeze from its ARM rivals, says *Matt Hanson*

For perhaps too long, Intel dominated the CPU market for Windows laptops and PCs. If you were buying or building a new computer, you'd almost certainly be slotting an Intel chip into the motherboard. But one company having such dominance isn't a good thing. It restricts choice for consumers, and the market leader can get complacent.

Things are changing, however. A resurgent AMD is bringing the heat back to Intel with its Ryzen and Threadripper CPUs, and we're also seeing the rise of non-x86 ARM processors. Usually found in mobile and embedded devices, a new generation of ARM processors is now powering laptops, lead by Qualcomm. With the likes of Microsoft and Lenovo supporting this new breed of laptop, it looks like the way we use those devices could change forever, and Intel needs to adapt—or die.



Qualcomm is a US company that used to be best known for creating telecommunication equipment. Its Snapdragon System on Chip (SoC) platform powered some of the most popular smartphones in the world. Part of the appeal of Snapdragon-powered smartphones was that, thanks to Qualcomm's hardware, these devices could handle many tasks that we used to use computers for. Suddenly, we were checking emails, browsing the web, and posting cat pictures on social media using our smartphones. Laptops began to fall out of vogue.

For the past 40 years, laptops have pretty much kept the same form factor. Sure, 2-in-1 laptops with 360-degree hinges and removable keyboards (such as Lenovo's Yoga series or Microsoft's Surface Laptop respectively), offered slightly different spins on the tried-and-tested laptop design, but on the whole, laptops hadn't changed much. You got a screen and keyboard in a clamshell design, and they were usually powered by Intel processors and integrated graphics. They became safe and boring, especially compared to high-end smartphones, and the laptop market declined accordingly.

However, at Computex 2017, Qualcomm and Microsoft announced a new breed of laptop, powered by the Snapdragon platform. Instead of smartphones taking features from laptops, we saw laptops from manufacturers such as HP, Lenovo, and Asus taking inspiration from smartphones.

© INTEL

Project Athena could be Intel's way of combatting the rise of Qualcomm-powered laptops.

This first wave of Windows on Snapdragon (WoS) devices were built on the octa-core Snapdragon 835 SoC. Originally designed for flagship smartphones such as the Samsung Galaxy S8, the Snapdragon 835 was a 64-bit ARM processor that used Qualcomm's in-house Kryo 280 cores, and was built using Samsung's 10nm FinFET processor.

These ARM-based laptops brought features we'd come to take for granted on smartphones, such as almost instant boot times, always-on cellular data connection, and battery lives far in excess of anything an Intel-based x86 laptop was capable of, with claimed battery lives of over 20 hours.

The Snapdragon 835 SoC also ran a lot cooler than x86 hardware, which meant manufacturers could forgo fans—leading to thinner, lighter, and quieter laptops.

The HP Envy x2 and Asus NovaGo were two of the first Snapdragon-powered laptops, and they certainly delivered on some promises—battery lives lasted around 20 hours, and the always-on 4G cellular data connection meant you could instantly get online almost anywhere without having to find and log into Wi-Fi networks (good for the security-conscious, as it meant you could avoid potentially compromised Wi-Fi hotspots).

However, they were far from perfect. When it came to performance, these non-x86 laptops couldn't keep up with Intel and AMD-powered machines. While Microsoft worked hard to make a version

SOFTWARE SUPPORT

Perhaps the biggest hurdle for non-x86 laptops is software support, because the vast majority of PC software is written for 64-bit and 32-bit Intel and AMD hardware. In the past, this has meant that laptops running on non-x86 hardware have been restricted by what kind of hardware they can use. However, that is all changing. Microsoft has been pushing Windows on Snapdragon and Windows on ARM development, which are versions of its Windows 10 operating system that are designed for non-x86 hardware. It brings a Windows desktop experience you'd expect on a laptop—and there's a growing number of apps on the Microsoft Store that can run on these devices. There are still noticeable absences, but Microsoft is making it easier for developers to recompile their win32 or Universal Windows Apps to become ARM64 apps, so they can run on 64-bit ARM hardware. It is also introducing emulation for win32 apps to run on ARM hardware—which will expand the software available for Windows on ARM devices without impacting performance.

If Apple does move to its own non-x86 hardware for MacBooks, we should see the company port its apps to the new hardware (and encourage third parties to do the same). We know that Apple is working on Project Catalyst, which will allow developers of iOS apps for iPhone and iPads to easily convert their apps to work on macOS. If future Macs run on similar architecture to Apple's mobile devices, Project Catalyst will ensure there is a wide variety of software ready to go.

The growth of web apps, which can run through a web browser, also means that many traditional restraints for non-x86 hardware will no longer apply.

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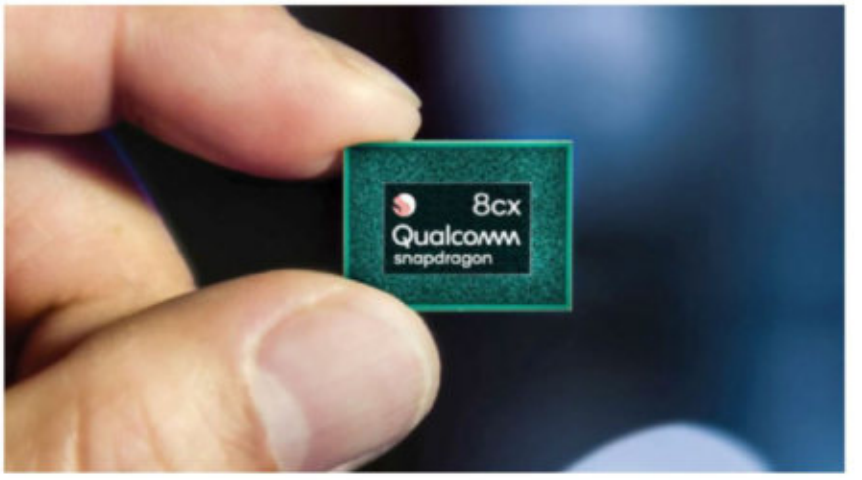


© QUALCOMM

The Snapdragon 8cx is Qualcomm's next-gen platform, designed for laptops and PCs.

of Windows 10 that worked on non-x86 gear, it struggled with even simple tasks.

Worse, these laptops were incredibly expensive, considering the level of performance you got. While they should have been priced around the same as a low-end Chromebook, they ended up costing closer to $1,000—and for that money you could buy a high-end Intel laptop that would blow the Snapdragon-powered device out of the water.

Still, they were doing something new, and they hinted at the possibilities of non-x86 Windows laptops.

Qualcomm continued to refine its Snapdragon platform for laptops and smartphones. The octa-core Snapdragon 845 came out in December 2017, and brought with it both performance and battery improvements.

In 2019, Qualcomm produced its best Snapdragon SoC yet with the Snapdragon 850 platform. It brought a 30 percent increase in performance compared to the previous generation, and offered 25 hours of battery life. It also came with an improved modem for faster 4G LTE speeds, thanks to the Snapdragon X20 LTE modem, which offers peak downloads of 1.2 gigabits; it's also better at performing in areas of weak signal.

The boost in performance also brought support for 10-bit HDR video content and surround sound. While these are things we've come to take for granted in modern laptops, previous WoS notebooks lacked the oomph to deliver a decent experience.

So, although earlier Snapdragon-powered laptops didn't do anything to challenge the dominance of x86 hardware, the improvements promised by Snapdragon 850 could give the likes of Intel and AMD reason to worry.

What's really exciting is that in our experience, the Snapdragon 850 really does deliver on those improvements. We've been playing with the Lenovo Yoga C630, and the improvements over the HP Envy x2, which runs on the Snapdragon 835, are very impressive.

In Geekbench 4, the HP Envy x2 scored 770 (single-core) and 3,116 (multicore), while the Yoga C630 easily surpasses it with a single-core score of 2,291 and a multicore score of 7,101. In our day-to-day experience using both laptops, we were seriously disappointed with the Envy x2, but the Yoga C630 managed what previous Windows 10 on ARM laptops failed to do, combining smartphone-like connectivity and battery life with performance that's not too far off x86 laptops.

This leap in performance for the Snapdragon platform should get Intel worried. But what comes after it could really make Team Blue sweat.

THE FUTURE OF SNAPDRAGON

While the Snapdragon 850 represented a big leap in making non-x86 laptops a more viable alternative, it was still held back by one major compromise: The 850 SoC was first and foremost a chipset for smartphones and tablets that is also used for laptops. However, in 2019, Qualcomm

Windows on ARM brings the Windows 10 desktop experience to non-x86 hardware.

INTEL'S RESPONSE

The rise of non-x86 laptops, especially ones powered by Qualcomm, has inevitably lead to Intel shaking off its complacency and moving to counter the threat of this new hardware. While it hasn't explicitly admitted so, its Project Athena initiative is a response to the rise of non-x86 hardware. If you've not heard of it, Project Athena is a laptop design initiative that will see Intel work closely with a number of laptop manufacturers to help shape the future of laptops by offering products that are smarter, faster (thanks to 5G), and more power-efficient—so battery lives are much longer. If always-on, always-connected laptops with long battery lives sounds familiar, it's because that's exactly what Qualcomm's Snapdragon platform offers. While Intel's focus on those aspects could be coincidental—or simply a response to what customers are now wanting from laptops—we can't help but think it is also driven by the threat posed to its market share by this new breed of laptop.

Intel has suggested that initial Project Athena laptops could release as early as the second half of 2019. However, if that's the case, then we wouldn't expect to see any Project Athena-certified laptops until very late this year.

According to Intel, "the next wave of Project Athena designs" will come in "2020 and beyond," so expect to see Project Athena laptops from manufacturers, such as Asus and Acer, next year. Whether or not they can compete with Windows on Snapdragon laptops remains to be seen. But if Intel can come up with laptops that feature the best of what Snapdragon laptops offer, without the compromises—due to them still running on Intel hardware—it could have a hit on its hands.

announced the Snapdragon 8cx, which will be the first chip it's produced that is designed specifically for laptops and computers. Without the constraint of it being a smartphone chip retrofitted for laptops, the 8cx has the potential to really make non-x86 laptops mainstream.

Qualcomm also beat AMD and Intel to the punch, because the 8cx contains the first 7nm processor for laptops and Windows devices: the Kryo 495. Meanwhile, Intel is still working on its 10nm architecture.

That's a pretty big PR blow Qualcomm has landed on its competitors, but not only does the smaller architecture look good on paper, but it should bring some real performance benefits as well.

It's based on ARM's big.LITTLE compute system, which combines slower processor cores with faster and more power-hungry cores, and switches between them, depending on the workload, to help maximize battery life without impacting performance, and will support up to 16GB of DDR4 memory, NVme SSDs, and Gen 2 USB-C 3.1.

For owners of Intel-powered laptops, that kind of feature list might simply elicit a small shrug—after all, x86 laptops have had those features for a while now. However, it's another step toward Snapdragon and other ARM-powered laptops challenging the current dominance of Intel-based hardware.

The 8cx's Adreno 680 graphics card also offers a decent leap in performance—including DirectX 12 support—so we could even see Snapdragon laptops that are capable of a little light gaming as well. It can also apparently power two connected 4K HDR monitors, too.

Snapdragon-powered laptops have SIM card trays for mobile connectivity.

However, arguably the Snapdragon 8cx's most important feature is its support for 5G mobile Internet. The speeds and low latency afforded by the emerging cellular data technology could have huge implications for how we use our computers. For instance, it could mean that we would be able to use our 5G laptops to stream games from services such as Nvidia GeForce Now or Google's upcoming Stadia service—so the lack of a powerful GPU wouldn't even be an issue. The idea that Snapdragon 8cx-powered laptops could become lightweight gaming machines that can play games at full graphical settings—and also have battery lives of over 20 hours—is an incredibly exciting one.

At Computex 2019, Qualcomm and Lenovo announced that they were working on "Project Limitless," which will be the first ever 5G laptop—and it will run on the Snapdragon 8cx platform.

According to Johnson Jia, senior vice president of Lenovo's PC Business Group, "Lenovo 5G PCs built on the Snapdragon 8cx 5G compute platform will feature ultra-low latency, remarkable performance, battery life, and 5G connectivity that will revolutionize the way we work and play."

That's a big promise, and while we don't know much more about Lenovo's Project Limitless, we should hopefully find out more later this year.

IS THE TIDE TURNING?

What the latest Snapdragon platform (and the future 8cx) demonstrates is that ARM-based laptops are finally viable propositions. They are no longer over-

INTEL PROJECT ATHENA FEATURES

To release a laptop as part of Project Athena, manufacturers will have to meet certain specifications, and this is what Intel has revealed so far....

5G connectivity: One of the biggest features of Project Athena will be 5G connectivity. This means that every Project Athena laptop will come with the ability to connect to 5G cellular networks (via a SIM card).

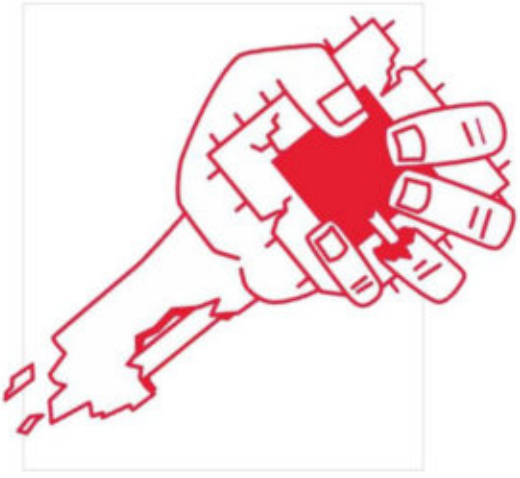
Longer battery life: Improving the battery life of laptops has been a constant struggle for manufacturers. With laptops getting ever thinner, the space to add batteries shrinks as well. Project Athena aims to drastically improve the battery life of laptops, with times between charges of around nine hours, which is a lot longer than modern Intel-based laptops. However, Snapdragon-based laptops have seen battery-life figures of beyond 24 hours.

Instant-on: Smartphones and tablets have spoiled us when it comes to devices that power up almost instantly, and Project Athena aims to bring that to Windows-based laptops and Chromebooks with Intel hardware inside. Again, Windows on ARM devices already manage this, and they also remain connected when in sleep mode, so emails can continue to be downloaded, for example, which means that when you open up the laptop, your emails are already there. We hope—and expect—Project Athena will offer similar functionality.

Intel hardware: We also expect Intel to set minimum hardware specifications, such as including SSD storage and support for Wi-Fi 6, the latest wireless networking technology.

Price-wise, we expect Intel Project Athena laptops to be pitched at the higher end of the market—much like when it created the Ultrabook category of laptops. However, Intel has talked about how Project Athena will cover a range of laptop types—and that Athena laptops will run Windows 10 and Chrome OS. Coupled with the fact that Google is one of the Project Athena partners, it looks like we'll be getting Project Athena Chromebooks—which means there's a good chance we'll see affordable Athena laptops as well.

The Lenovo Yoga C630 is one of the best Snapdragon-powered laptops out there.



ZombieLoad: the latest bug to hit Intel CPUs.

priced and under-performing curios, but laptops that offer genuine alternatives to x86 machines.

Could that lead to more laptop manufacturers looking at leaving Intel and AMD, and using ARM hardware in their products instead? Perhaps. Intel hasn't been doing a fantastic job of keeping manufacturers onside, due to a number of high-profile security flaws in its chips. Meltdown and Spectre made the headlines last year, and ZombieLoad was recently discovered, leading to many manufacturers and software developers having to scramble to provide patches to mitigate against the vulnerabilities.

Not only do these flaws annoy manufacturers, who feel they have to work to fix Intel's problems, but most of the fixes involve disabling Hyper-Threading, a feature that generates virtualized processor cores for improved multitasking, and that has led to some drastic performance impacts after the patches are applied.

For example, Apple revealed that, with the ZombieLoad patch installed, there could be performance drops of up to 40 percent—which would particularly impact Macs with multicore processors.

Not only will this annoy customers, who are seeing their expensive devices perform worse, but it's not a good look for the manufacturers, either. If your Mac suddenly starts running slow, you're likely to blame Apple before you blame Intel.

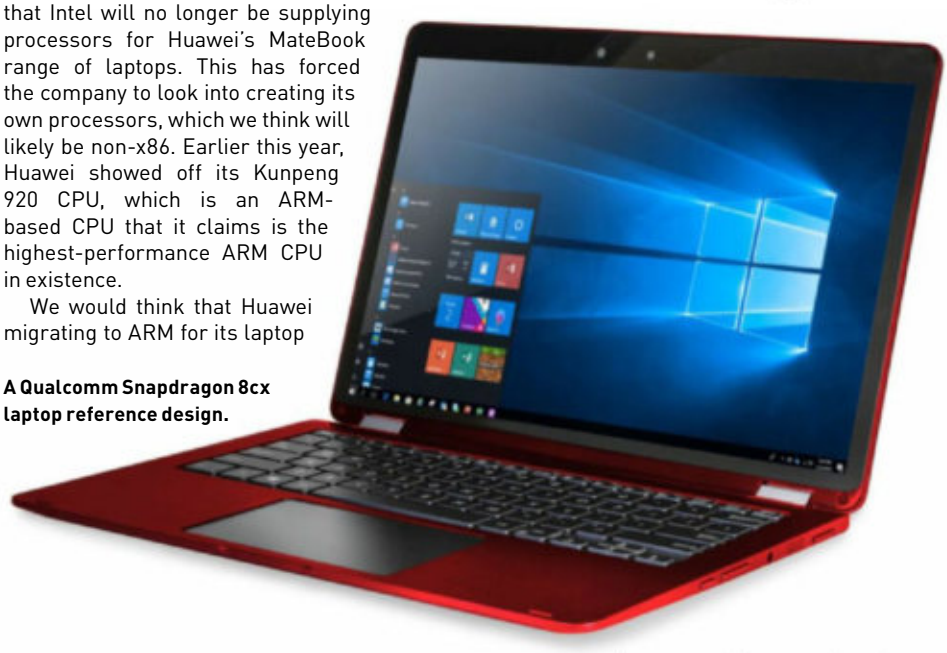
Speaking of Apple, rumors have continued to grow that the company is looking to part ways with Intel and produce its own custom ARM-based chips in 2020. Apple is a company that likes to keep control over all parts of its hardware, so we think this is an increasingly likely possibility. Not only will the company have been nonplussed about having to throttle the performance of its Macs due to ZombieLoad (which does not affect AMD and ARM processors), but it also recently suggested that the drop in Mac sales was due to "processor constraints in the March quarter, leading to a 5 percent revenue decline compared to last year." The fact that Tim Cook himself was all but calling out Intel doesn't bode well for the relationship between the two companies.

If a company as big as Apple ditches Intel for ARM, we could easily see other companies following suit.

Another laptop manufacturer that is set to move from Intel to its own processors for its laptops (but for very different reasons) is Huawei. You've probably seen the news about the US government's blacklisting of the Chinese company over espionage fears, and it has resulted in most US (and UK) companies ceasing business with it. This means that Intel will no longer be supplying processors for Huawei's MateBook range of laptops. This has forced the company to look into creating its own processors, which we think will likely be non-x86. Earlier this year, Huawei showed off its Kunpeng 920 CPU, which is an ARM-based CPU that it claims is the highest-performance ARM CPU in existence.

We would think that Huawei migrating to ARM for its laptop processors would be a no-brainer in light of its recent troubles. The only problem is that ARM has also said that it will stop working with Huawei. This could have huge implications for both companies—though especially Huawei, which will need to look at building its own RISC-based CPU from the ground up.

So, the future of non-x86 Windows (and Mac) laptops certainly looks bright. While we don't expect Intel-based machines to suddenly disappear from the laptop landscape altogether, the fact that we're going to be given more choice is certainly welcome. The fact that these ARM-based alternatives are bringing some genuinely innovative new features to the rather staid laptop form factor is also to be celebrated—and with Intel's once unassailable dominance now under threat, we're looking forward to seeing how the chipmaker responds. All of a sudden, laptops are exciting again.



A Qualcomm Snapdragon 8cx laptop reference design.

TECH PORN

2 POWERHOUSE

The slender battery inside the Swift 7 packs a punch, capable of running for up to 13 hours between charges. Acer designed this laptop for office workers on the go and visual content creators, and as such it comes loaded with an 8th-Gen Intel Core i7 processor, easily capable of supporting the day-to-day needs of a working professional on the move.

1 SCREEN TIME

This IPS full HD touch panel provides staggeringly true blacks and vibrant color. Thanks to an ultra-thin black bezel, this 14-inch screen looks almost borderless. With a 0.4mm layer of Corning Gorilla Glass protecting the layer of touch-sensitive capacitive film and the 2mm display, it promises to be durable, too.

Acer Swift 7

ACER'S NEWEST LAPTOP is undeniably a work of art. Measuring less than half an inch thick and weighing under two pounds, just picking it up made our hearts leap. No expense has been spared in making the new line of Swift 7 notebooks as sleek and weightless as possible; they're composed of ultra-lightweight magnesium alloys rather than conventional aluminum, and pack thinner components than some phones.

The heat pipe is only 0.8 millimeters thick, and the three-cell 32Wh battery is thinner than a typical coin battery. The Swift 7 is fanless, instead using a copper-graphite composite thermal pad that distributes heat across the entire chassis. This ensures completely silent operation and helps prevent dust buildup inside the Swift's compact casing.

Like many upcoming laptops, security features play a key role in the Swift 7's design. The HDR camera sits just above the keyboard, hidden beneath a pop-out button that points up at 55 degrees while active. When not in use, the camera is effectively contained within the chassis. The power button is integrated into the fingerprint scanner to save space and keep the keyboard area tidy, and pressing Fn-R instantly darkens the screen.

With 8GB of dual-channel RAM and 512GB of NMVe storage, the specs are fairly impressive, too. In terms of graphics, this little beauty runs on integrated, using Intel UHD Graphics 615. No, it's not going to run *Crysis*, but it'll handle picture and video editing with ease. –**CHRISTIAN GUYTON**

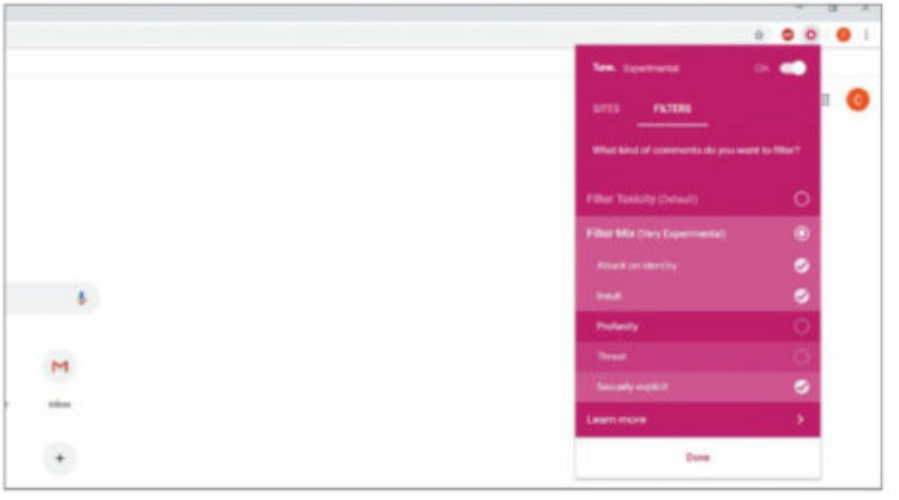
3 STAYING CONNECTED

The Swift 7 doesn't have a conventional USB port; in fact, it has very little whatsoever in the ports department. A single 3.5mm headphone jack sits on the left-hand side, while here on the right we have two high-speed Thunderbolt 3 ports. Don't worry, though—the Swift 7 includes a dongle for both USB and HDMI access.

HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH



GOOGLE TUNE EXTENSION

Internet got you down? Sick of the relentless stream of vitriol that social media commenters spew out day after day? Good news, Chrome users: An experimental new extension, Tune, uses machine learning to filter out profanity and toxic comments on websites such as Facebook, Twitter, and Reddit. You can manually set the level you want to see, from full exposure to a peaceful "Zen" mode.

MAKE – USE – CREATE

CHRISTIAN GUYTON
STAFF WRITER

BUDGET BATTLES

This month, we've been squeezing our wallets to make every cent count. I was responsible for our cover feature, where we endeavored to build a reasonably nippy work computer within a tight budget. Elsewhere, we've got a guide to budget VR on your smartphone, and a comparison of affordable GPUs in our "Head to Head." It feels a bit like this is the "let's spend less money" issue, which is a mindset I'm sure our bosses could happily get behind.

With prices in constant flux, it's good to see that PC building isn't overly expensive. There's plenty of cool stuff soon to come, too: AMD is bursting out with the Ryzen 3000 series and Navi coming soon, while Nvidia is teasing its new "Super" project. There's lots to be excited about, and not just for high-end hardware. There's never been a better time to work on a 1080p or 1440p gaming rig.

If—like me—you're rocking an older rig (my home PC has an i5-7400 and a GeForce GTX 1060), it's worth getting ready to upgrade. I was hoping for a sensibly priced GTX 1670 from Nvidia, but it looks like the green team is moving on to bigger and better things. We've recently enjoyed a variety of game bundles with GPUs and CPUs, too, so hopefully that will hold true of any new products.

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

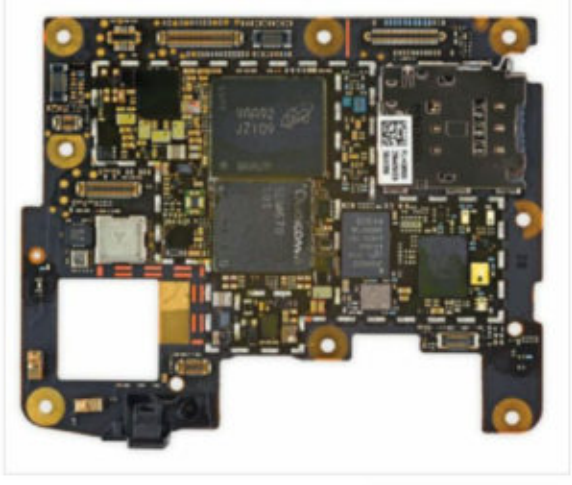
IFIXIT presents:

AUTOPSY

THIS MONTH WE DISS

Google Pixel 3a

Although it would help, this phone was easy to open without heat.



This time around, we don't get a peep at Google's Pixel Visual Core.

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.

BACKGROUND

The Pixel 3a breaks all the rules—a polycarbonate back panel, no wireless charging, visible bezels, a headphone jack, and a top-notch camera in a budget phone. Is there a method to Google's madness? Let's find out....

MAJOR TECH SPECS

- 5.6-inch OLED display with FHD+ 2220×1080 resolution (441 ppi) and Dragontrail Glass
- Octa-core 64-bit Qualcomm Snapdragon 670 processor (2.0GHz + 1.7GHz) with 4GB LPDDR4x RAM
- 12.2MP f/1.8 OIS main camera with dual-pixel phase detection autofocus; 8MP selfie camera
- 64GB built-in storage
- USB-C and a mysterious 3.5mm "headphone jack"
- Android 9.0 Pie

KEY FINDINGS

- The polycarbonate build should be more durable than a glass back, but it's likely no match for the rigidity of the metal construction of yore. Meanwhile, this Pixel's party piece—a rear camera like the one in the rest of the Pixel 3 line—promises serious firepower for a budget phone.
- Turning to the front, the 3a looks much like the Pixel 3, but with fewer seams. That seamless enclosure points to a screen-first entry—we're hoping it means easier screen replacements than on the Pixel 3. From the back, it's hard to tell the 3 and 3a apart. The Pixel 3a packs a slower processor and plastic construction, among other changes, to bring the price down a ton.
- A spongy, easily separated adhesive secures the display, which is good for repairs, but probably leaves the phone less than waterproof. We safely slice alongside the display and free it from the phone. Like old times, the display is connected to the mobo by a ribbon cable. Also along for the ride is a Synaptics S3706 touchscreen controller.
- On our way to the battery, we fold aside a couple of golden flex cables for the Active Edge sensors. In Pixels past, these were routed under the battery; easy to destroy with prying. It's nice to see them out of harm's way. Onward to battery extraction, where two adhesive strips stand in the way. We locate the pull tabs and they co-operate with little fuss. This battery beats the Pixel 3's 11.2Wh one with its own 11.55Wh powerhouse, falling between the iPhone XR and Galaxy S10e, at 11.16Wh and 11.94Wh respectively.
- The 3a inherits the well-reviewed 12.2MP rear camera from the Pixel 3. Instead of two 8MP selfie cameras, the 3a has only one, averaging the f/1.8 and f/2.2 apertures to f/2.0. We fish out the fingerprint sensor, complete with its wavy tail flex cable. At the bottom is a modular USB-C port, a welcome design for this high-wear component, especially as the 3a doesn't offer wireless charging. The headphone jack also makes a cool modular comeback.
- Repairability score: 6 out of 10 (10 is easiest to repair). Most components are modular and easily replaced once the display is removed. Repair-friendly stretch-release adhesive secures the battery. The only screws are standard T3 Torx ones. The display comes off first, but is thin and poorly supported. Foam adhesive makes opening easy. The myriad long, thin ribbon cables connecting the internal componentry can be obnoxious to work around.

Beautify Your Games with ReShade

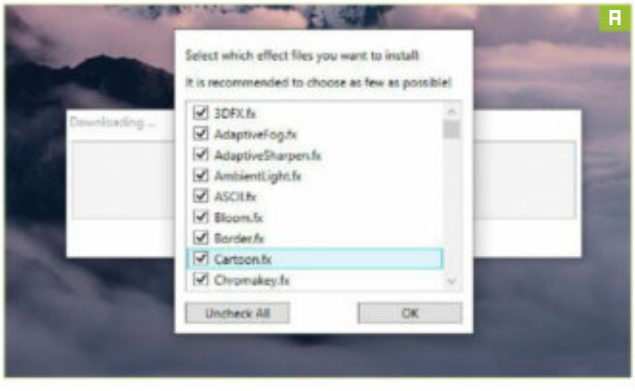
YOU'LL NEED THIS

RESHADE
Download it from http://reshade.me.

A DISCRETE GRAPHICS CARD
Virtually any card should work, but you'll get better results on more modern hardware.

AS PC USERS, WE'RE PRETTY LUCKY. Virtually every game gives us options. We can customize our control scheme, we can mess with config files, and we can adjust graphical performance, often to the most minute degree. Try doing that on a console. But let's face it: Sometimes those options aren't enough. We've invested in high-end graphics cards that can cost more than a decent used car, so we should be able to abuse them in any way we see fit. That's where ReShade comes in. It's a post-processing injector, meaning it sneaks its way in between your game and your graphics card's final render to screen, enabling you to add your own effects and shaders to the eventual output.

Want to add depth of field to an older game? Sure, why not? Want to tweak the colors of a dim game and brighten it up? You can do that while adding little to no performance overhead. Want to use ray tracing in a game that wouldn't otherwise support it? Even that is (sort of) possible with Pascal Gilcher's experimental global illumination shader, available through www.patreon.com/mcflypg. The only thing ReShade can't do is improve gaming graphics while running on integrated hardware—you need to upgrade for that. –ALEX COX



1 THROW SOME SHADE

It's important to note that we're not running ReShade on any kind of ludicrous hardware—our test machine here is a lowly Core i5-4590 with an affordable bus-powered Nvidia GTX 1050 Ti on board. Only the latter is really tested, given that ReShade is mostly GPU-bound, but it's going to mean you asking slightly more of your hardware, and just how much extra processing it demands depends on the particular shader you employ. That said, you might actually be able to improve performance if you switch out certain in-game rendering options for ReShade's more efficient post-processing shaders. Switch off antialiasing, for instance, and instead pour on some FXAA after the fact, and you may well discover an extra lick of speed.

›› Let's begin by getting ReShade installed. It's not a traditional program, or even a traditional driver, and you don't install it in the same way. Instead, you need to individually apply ReShade to each game you want to use it with. This makes sense: You might not want to use the same collection of shaders on one game as you do on another, and indeed you might not want ReShade layered on every single game. It's not difficult: Download the setup tool from http://reshade.me and save it somewhere safe, as you need to run it for each game you want to tweak. Run it, hit the button, and find the game you want to tweak—by default, it opens the "steamapps/common" folder on your boot drive, so dig into the appropriate folder, and select the executable of the game.

2 VERSION OPTIONS

Next, select whether your game uses Direct3D 9, Direct3D 10+, or OpenGL—if you don't know which option to choose, check out ReShade's compatibility guide at http://reshade.me/compatibility. If your game isn't there, opt for D3D10+ and reinstall later if it's incorrect. ReShade can only work with games using D3D9 or above, because it literally intercepts calls made to the rendering API. If you're trying to jazz up something older (such as, for example, the earlier 3D *GTA* titles, which use Direct3D 8), you need to grab the d3d8to9 wrapper from the tab at the top of http://reshade.me, and drop it in the root folder of your game. Want to go even earlier? Direct3D 7 and above aren't supported, but some games have had their own API upgrades in the intervening years. If there's a D3D11 version, use that.

3 CHOICES, CHOICES

At this point, you're offered the opportunity to download a collection of standard effects [Image A]. These are, although sometimes a little behind the curve in terms of their development, pretty decent, and they cover a broad range, so we recommend clicking "Yes" and downloading these to start—we'll extend ReShade's abilities with a selection of more complex shaders later. You're given the option to select which to install; while ReShade suggests picking as few as possible, we encourage you to go crazy this first time, and install all of them, because they can be enabled and disabled at will. Once the ReShade window switches to "Edit ReShade settings," you're ready to go: You can launch your game as normal. You'll know ReShade has installed correctly if you see a new overlay appear along the top of your game.

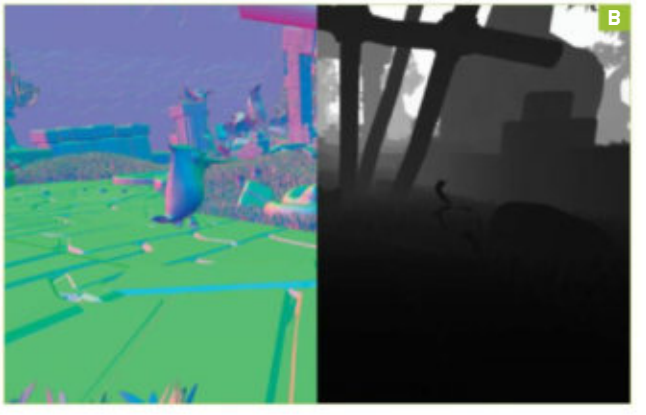
4 LAYER IT ON

Hit Home on your keyboard, and ReShade pulls mouse focus from your game, and automatically starts a tutorial. Step through it until you click "Finish." You're now ready to apply your first shader. But which

MULTIPLAYER MADNESS

ReShade is a clever piece of software, but perhaps slightly more clever than many developers would like. It's able to peer into the depth map of your games and act on that information in a live manner—which is fine if you're playing by yourself and just want some fancier graphics, but not so fine if you're playing multiplayer games where depth map manipulation could offer you an unfair advantage. It's the kind of thing that cheat engines were built to sniff out—and it's so hated that it's entirely banned in *PUBG*, among other games.

While most multiplayer games do a fine job of disabling access to the depth buffer, if you'd like to keep your account intact, it's probably a good idea to avoid installing ReShade on anything even slightly sensitive. If you do, avoid going online—and if you must, uninstall ReShade before doing so. You can take a copy of your settings by backing up the reshade.ini and DefaultPreset.ini files, copying your "Shaders" folder, then removing ReShade by simply deleting its DLL files and their associated INI files: Look for d3d8.dll, d3d9.dll, dxgi.dll, and opengl32.dll. Run the game again, and ReShade will be gone; just reinstall with the usual installer, and replace your backed-up files.


B

will it be? Realistically, that's up to you. The default pack includes a number of shaders that aren't of much practical use, although they're rather artistic, but there are a few that can produce some impressive effects. Take your pick; flick one on by checking its box, and you should see the effect immediately. If it's not strong enough, start playing with the sliders in the lower part of the ReShade interface; you can always revert to the original settings by clicking the button at the top. Hit Home to give focus back to your game, and close the ReShade menu.

›› ReShade's filters work top-down, in layers. If you enable more than one, you may wish to sensibly reorder them by dragging them in the list. Obviously, the specific order depends on the specific filters you're using, but in general you'll want to put ambient occlusion filters first, sharpening next, antialiasing third, and any color tweaks last on the list. That's the logical order, at least, but it's going to be a process of experimentation to find the one that works best for your game.

5 FIGHTING FRAMES

With a few filters installed, you may find your frame rate dropping slightly. Even the order those shaders run in can have a big impact on performance. But to see what they're really doing, you need to head to ReShade's "Statistics" tab. The top of it shows your current FPS and, notably, the time each frame has taken to render—if this goes up, the former goes down. Below, click "Show only active techniques," and you can see statistics on just what impact each of your shaders is having, with a live update of the time they've added to each frame render, and the number of passes each takes. But that's not all—many shaders show you exactly what they're rendering if you hover over one of their layers. Double-click one, and you can pop it out in a window of its own, giving you an overlaid peek into the inner workings of ReShade.

6 WHAT'S THE PROBLEM?

Some shaders also have a debug mode. Try, for instance, enabling SMAA, and using the drop-down box at the bottom of its settings panel to switch on "View edges"—you see only the edges it detects (and antialiases) drawn on screen, giving you the chance both to refine the rest of its settings with a visual indicator of what's going on and to play any game as though it's an awkwardly colored analog of the old wireframe *Star Wars* arcade game.

›› Debug options can also be handy if you're having problems with certain shaders. If, for example, depth-based shaders such as MartyMcFlyDOF aren't functioning, enable the DisplayDepth shader, and set its "present type" function to "Vertical 50/50" to see the


C


D

BETTER SHADERS

There are some dedicated ReShade fans out there who have used its internal programming language to create not just preset packs, but brand new shaders, too—and some of them outshine the default set by a huge degree. We've talked about the Quintessential Shader Pack, but that's just the tip of the iceberg. Why not try Loadus's PandaFX shader (https://pastebin.com/L8tv3R4j), which applies a whole host of cinematic effects (including a whole lot of blur, if that's your thing) in one handy easy-to-use package? Perhaps you're desperate for your games to look as though they're recorded on a VHS tape—then https://bit.ly/2HKdYTK is for you.

If you're not lucky enough to have a monitor that updates at 144Hz, but you're playing games with frame rates way above 60Hz, you may be cursing those lost frames. So, do try using ReShade to blend them together, putting all that frame data on screen at a rate your monitor can handle. Madness, yes, but possible if you use ShoterXX's experimental High-Framerate Frame-Blending shader. Grab the code from https://bit.ly/2WAoDZm and save it as a .fx file in your shader directory. It'll make things much blurrier, but a whole lot smoother.

detected normal map and depth map on screen [**Image B**]. If this is blank, it's likely that access to the depth buffer is blocked—see the "Multiplayer Madness" boxout for clues as to why that might be. Alternatively, you may need to let ReShade know exactly which layer is the correct depth buffer to use. With DisplayDepth activated, head over to the "DX11" tab (or "DX9/DX10") and change which buffer is used; if you see a multicolored, untextured approximation of your game pop up, you can now safely disable DisplayDepth and work with whatever shaders you like.

7 A SAMPLE SELECTION

Let's quickly compare a game with and without ReShade effects by gussying up *Grid 2*, which is impressive-looking but, given its age, not the most demanding game on modern hardware. We've turned everything up to maximum, but switched off antialiasing and ambient occlusion in its in-game settings panel, in order to let ReShade do that work for us—*Grid 2* has a tendency to look a little soft even without its built-in filters [**Image C**], so it's a good choice for tweaking.

» The first thing to enable is MXAO, ensuring the correct depth buffer is used by enabling the debug view, and selecting the appropriate one on the "DX11" tab. Dragging the amount slider gives us the option to select just how gloomy we want our dusky image to become. Next, a little sharpening: Drag the LumaSharpen shader below MXAO, and use its "Show sharpening pattern" setting to see its results. Adjust it until the game is suitably crispy—this gives the SMAA filter, which you should put next in the list, some good edges to smooth out. Next, we'd add the excellent MagicBloom filter, followed by Vibrance, and FilmGrain2, just for a little class. The effect ups the realism of the image [**Image D**], but it's not without its drawbacks: It dropped the frame rate of our sample location from 112 to 56, mainly thanks to the numerous frame passes required by MagicBloom, SMAA, and MXAO. Unless you're running some prodigious hardware, the same will happen to you.

8 SAVING SETTINGS

You've tinkered and tweaked. You've dragged sliders and set things just so. Helpfully, ReShade includes a preset system, which enables you to back up your settings and reload them at a later time—or even grab presets from folks online who've already done the tinkering for you. To save your current settings, open up the ReShade menu with Home, and click the plus sign at the top—give a name to your new preset, and you're saved. You can switch between different presets by clicking the arrows to the left of the preset name.

» And so to precompiled presets. Before we start playing with these, head over to http://github.com/martymcmodding/qUINT and download Pascal Gilcher's quintessential shader pack, a selection of highly refined shaders. Find the shader folder in whatever game you're going to use it on, and drop the six files from qUINT's shader folder in there—alternatively, you can put them in their own folder, and add them to ReShade's list via "Settings/Effect Search Paths." If you do the latter, hit "Reload" at the bottom of the ReShade menu to add them to the list.

9 BETTER PRESETS

With all the prerequisites lined up, head to http://stormshade.otakumouse.com/preset/photo-realism-v3-0 and download the preset there, just as an example. It's a shader specifically built for *Final Fantasy 14*, and one that's not specifically geared toward gaming, meaning it might look a little awful to start with—disable Mode1 and Mode2, and switch off ADOF, however, and you should end up with a pretty vibrant picture [**Image E**].

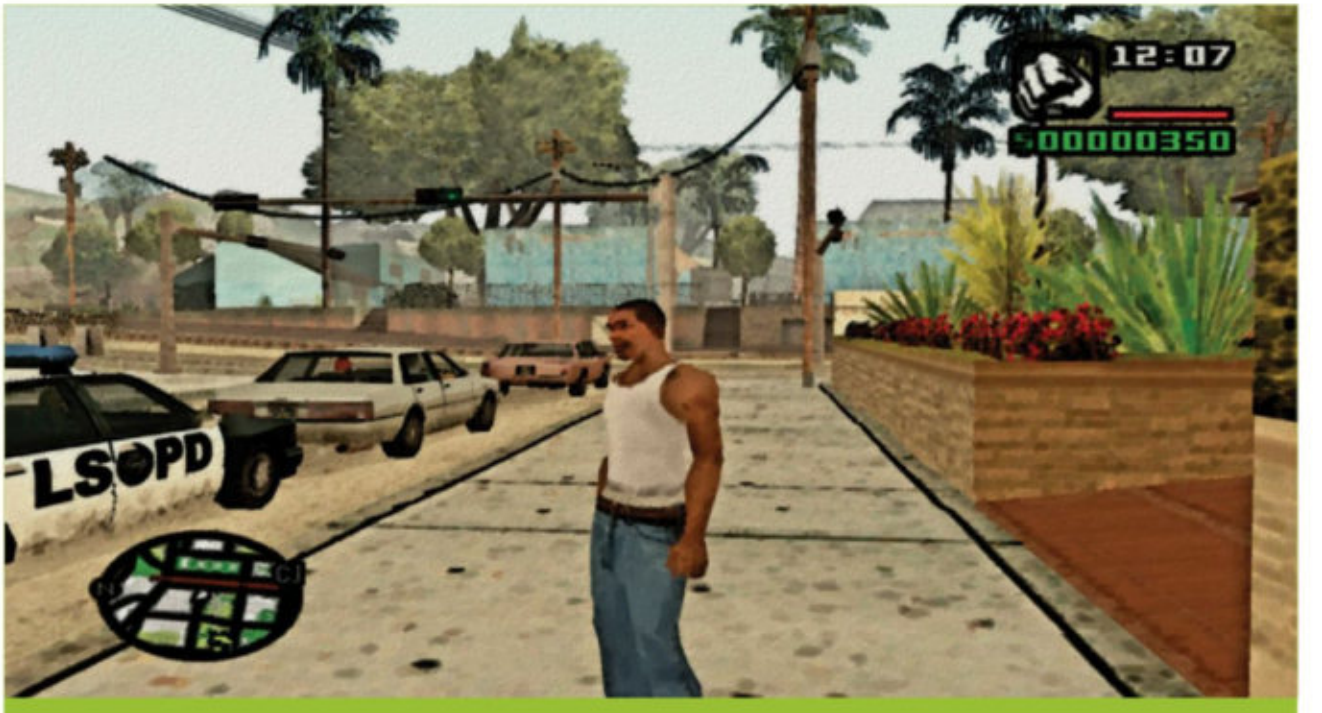
» Each game behaves differently—so you'll probably want to pull in a preset designed for the game you're trying to play, rather than cludging one through. Head to http://reshade.me/presets to see the database. Bear in mind that, if the dumpster fire of classic web coding on show here didn't previously clue you in, many of these are old. They're predominantly suited for ReShade's predecessor SweetFX, though that doesn't mean they're

completely unusable. You may (may) have some success porting these over to ReShade using TransMod (https://bit.ly/30T14dJ)—really, it's just a case of relabeling a few things in the config file, as many of the shaders in ReShade expect the same parameters and values, it's just the layout of the preset file that's changed.

10 SHADY ANNOYANCES

ReShade, it's fair to say, often doesn't play nice. Depth of field effects, in particular, rarely work as well as they should; we'd have brought you a guide to applying the seemingly excellent MartyMcFlyDOF shader, or its more developed successor qUINT_ADOF, had we not spent nearly a full day fighting with both, and eventually throwing in the towel. You, like us, will either need to put in a lot of time and effort getting things just so, or (when you're tired of banging your head against your keyboard) stick to lower-level effects that don't rely on the z-axis to function properly. Improve the color of your games, add beautiful bloom, sharpen those edges, and call it a day—often your games' built-in effects are far better than you would be able to achieve through ReShade anyway.

» Specific documentation for ReShade is sparse at best, but the forums at http://reshade.me/forum are a good place to head if you're having any particular problems, want to learn more about its workings, or are on the lookout for the latest shaders. It might also help to read up a little about techniques such as ambient occlusion, antialiasing, and so on, so you know what you're really doing when you drag those sliders.



OTHER OPTIONS

ReShade is not the only shader injector on the street, though it is perhaps the most user-friendly. You could, if you can find it, use predecessor SweetFX (and many do), though this needs to be fully set up and configured before playing, a process that is much more tricky than that of ReShade. A better option, if you have an Nvidia card, is to use GeForce Experience; it has its own shader engine, Nvidia Freestyle, which can be used in much the same way as ReShade. It's limited to a shorter list of compatible games, as opposed to ReShade's throw-it-at-it-and-see-if-it-sticks approach, and there's less complexity in terms of the reach of its shaders, but you get a much more professional presentation. Run GeForce Experience, make sure you're up to date on the latest Game Ready Driver, then use its interface to launch a compatible game (the list is at https://bit.ly/2MeH073). Hit Alt-F3 to jump into the game filters menu, and you can quickly set up one of three different filter layouts by using the "Add Filter" button. Ever wanted to play *GTA: San Andreas* as an animated watercolor painting? The time has come.

Turn an Old Phone into a VR Headset

YOU'LL NEED THIS

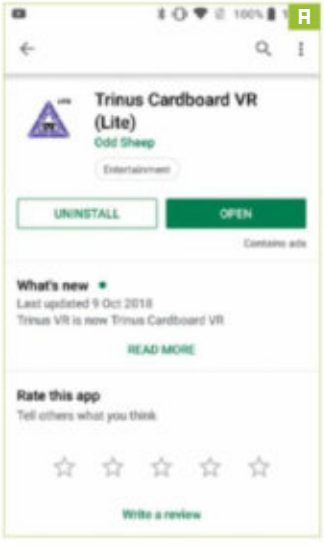
TRINUS CARDBOARD VR
Download the app from www.trinusvirtualreality.com.

A CHEAP HEADSET
A plastic version should cost around $10.

AN OLD PHONE
Any handset that can fit inside your headset will do.

VIRTUAL-REALITY HEADSETS ARE ALL THE RAGE THESE DAYS. Oculus can't help but release a new one every five minutes, Sony has its own for the PS4, HTC has a bunch, and even Valve is getting involved. But if you're willing to sacrifice graphical fidelity, responsiveness, convenience, and possibly your lunch, you don't actually need any of them. All you need is an old-ish phone, a very cheap set of VR goggles to slot it into, a whole lot of patience, and some massively lowered expectations.

But, although this is a very much botched version of VR, it is, nonetheless, definitely VR. And not just the big-screen gaming kind, either—we'll turn any old game with an accessible depth buffer into one with a proper stereoscopic 3D display; switch on the mouse sensor, and you can translate the phone's accelerometer into mouse movement, giving us some degree of head tracking to boot. Our target while running through this will be *GTA V*, because strapping on a headset only enhances its ludicrousness, though you could conceivably try it with any game. While there's no room-scale shenanigans, and you still need a controller to play, it's far cheaper than a full headset, and really just a bit of fun. **–ALEX COX**



1 MAKE THE LINK

First things first: Let's sort out a link between your PC and your phone handset. For this we'll use Trinus Cardboard VR and Trinus Server, the latter of which sits on your machine, while the former is an app downloadable on both Android and iOS phones. Note that there are a few different versions of Trinus; if you have a Daydream headset, you can take advantage of its extended capabilities by grabbing Trinus Daydream VR instead, and there's also a server version for PSVR headsets—we'll stick with the Cardboard version, as it's the most universally usable.

›› Head to the Play Store [Image A] or App Store and download Trinus Cardboard VR (Lite), the free time-limited version of the app. This will kick you out after 15 minutes, at which point you can reconnect again; as much as we'd encourage you to spend a little to get the full version, an enforced break after 15 minutes of low-resolution immersion probably isn't the worst thing in the world. On your PC, download the companion app from www.trinusvirtualreality.com and install it.

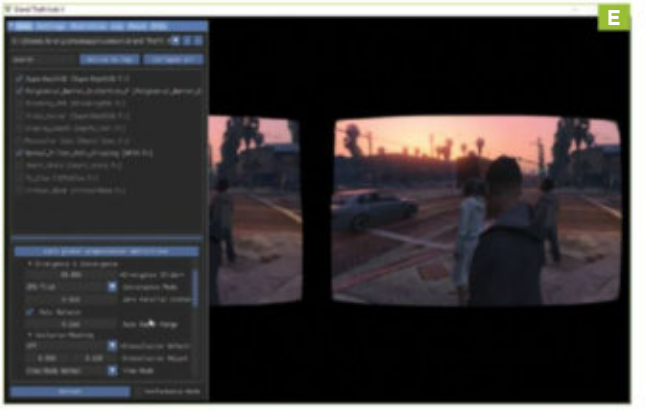
2 MAKE A CONNECTION

You have two options for connection: either Wi-Fi, which we'll use here, or USB, which can offer lower latency, but comes with the obvious disadvantage that you're tethered to your PC by a wire. When you're using Wi-Fi, you definitely want your PC connected to a wired network connection to ensure the only potential source of network disruption is on your phone's end. Fire up the Trinus app on the handset end, and you're told your phone's IP address; run the app on your PC, hit the triangular button on the phone to begin the connection, and you should find the PC app has detected the same IP. Set the capture mode to "General," and the sensor mode to "None," then hit the "Start" button on the PC end—you should see a portion of the Trinus server app streamed to your phone's screen.

3 QUESTIONABLE QUALITY

You'll likely notice that things don't look so great [Image B]. That's basically by design—in order to get the best performance, Trinus lowers the default resolution to a painful 752x406, and defaults to a high performance mode, which adds extra compression. You can alter this on both ends: On the PC, change the image scale to ultra, and drag the compression slider all the way to the right, then open the "Settings" menu on the phone, and change the performance mode to "Quality." Restart the server, and you'll see the resolution get much more crisp—though when you move the phone, you may notice blurring. This can be disabled by heading to the "Video" tab on the PC and switching off "Motion Boost." Bear in mind that everything we've just done you'll probably want to switch off very soon, but it's good to prove that it's possible.

© TRINUS CARDBOARD VR



4 TIME TO PLAY

Shut off the server, and go ahead and fire up a game. Put it in windowed mode, head back to the Trinus server app, and set it to Game mode. Link up the server and your phone, bring your game back into focus, and you should see it beamed across—but you'll notice a problem. It's not stereoscopic [**Image C**]. There's an easy way to fix this: Kill the server, head over to the "Video" tab, and switch on "Fake3D." This doubles the image for each eye, and it's the least processor-intensive way of getting immersive gaming going, but it doesn't do any stereoscopic depth processing, and it can't have escaped your attention that it's not scaled particularly well [**Image D**]. Even activating the lens distortion mode on the phone (which requires the "Performance" setting to be on "quality") doesn't fix this—if this is the mode for you, you need to adjust the resolution of your game to as square an aspect ratio as it can possibly manage.

5 DO IT BETTER

OK, we're here for proper 3D, and to get that, we need to use either Steam VR or, for the many games that don't support it, ReShade. If you want to use the former, make sure Steam is shut down, head to the "SteamVR" tab on the Trinus server app, install its SteamVR driver, then relaunch Steam, load SteamVR, and your headset should be detected.

» Much more interesting, though, is converting otherwise flat games to play in stereo 3D—this is a technique you can use with any old headset, so if you're dying to force depth into your Oculus Rift on games like *GTA V,* you're encouraged to follow along. Start by installing ReShade—grab the installer from http://reshade.me, and point it at the game you want to install. Don't worry about including any of the default shaders at this point, as they'll just clutter things up. Instead, head to http://github.com/BlueSkyDefender/Depth3D to download the Super Depth 3D shader pack, which includes everything you need. Point ReShade to its contents, then fire up your game.

6 GOING DEEP

Hit Home to open the ReShade overlay, and run through its tutorial screens. Switch on SuperDepth3D, and you should see your game switch to a stereoscopic view; this is derived from the game's depth buffer, which means it doesn't work with everything (and absolutely should never be used in multiplayer), but also means each eye is delivered a subtly different image—viewed together through Trinus in your headset, you should see depth. There are various settings you could tweak at this point; we found, testing in *GTA V,* that switching Auto Balance on made for a convincing depth effect, but it's not flawless. First-person view in cars, and the phone popping up, mess with the depth map, and can temporarily ruin the effect.

» Then layer on everything else. Polynomial Barrel Distortion [**Image E**] squashes the view into a lens-happy rectangle, which means you won't be dealing with a stretched peripheral-filling mess, and NFAA is all but essential if you don't want to see too many jaggies. Oh, and a virtual nose can help with the nausea—switch it on, because you'll probably need it.

3D ALTERNATIVES

If you've tried this sort of thing before, you might note a couple of changes in the DIY VR landscape. Probably the most major is the demise of TriDef, the company behind TriDef 3D and TriDef VR. Both enabled you to quickly convert almost any game into stereoscopic 3D or, in the case of certain OEM monitors, shutter-goggle 3D. These were commercial apps, and their requirement to phone home to TriDef's servers meant they died along with the company when it shut down.

With TriDef pushing up daisies, we've looked at using ReShade and SteamVR to process the signal, but they're not the only middleware options. If you're happy to shell out, it's worth looking at vorpX (www.vorpx.com), a $40 app aimed at thrusting more games into Oculus and Vive headsets that's still under active development. There's also Vireio Perception (www.mtbs3d.com), which is open source but cludgy, and looks like it hasn't seen a new version in three years. One thing that isn't an option, at least without serious hacking, is Nvidia's 3D Vision—though you might consider swapping Trinus for Gamestream, if head tracking isn't important.

Keep Up to Date with Flipboard

YOU'LL NEED THIS

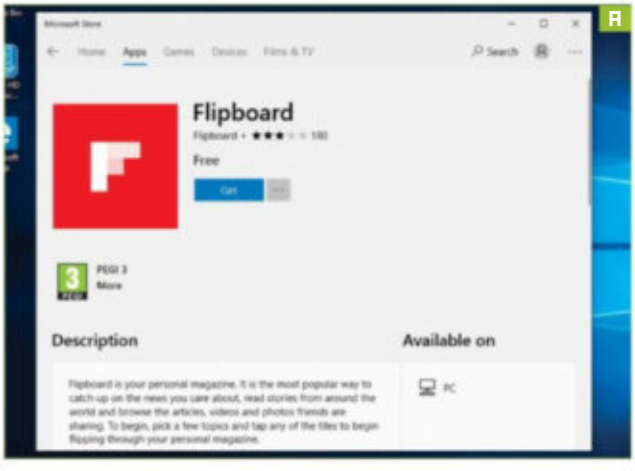
FLIPBOARD
Download the app from the Microsoft Store, or sign up via https://flipboard.com.

ONE OF THE MAJOR DRAWBACKS of the Internet is the sheer volume of new websites, blogs, and informative videos available. Flipboard is a dedicated app that helps you to make sense of all the material out there. It does this first and foremost through its intuitive search feature, which enables you to look for your favorite topics, then lists relevant articles and users who've assembled similar content.

Flipboard also helps you to stay on top of trending information by collating recent articles into a Daily Edition of the latest news and views. Once you've found a useful link, you can add it to a virtual smart magazine. There's no limit to what you can add or the number of magazines you can create.

You can use Flipboard's dedicated editor to configure and remove articles and magazines. This is a vital feature, because new users can sometimes become Flip happy, adding far more content to smart magazines than they can actually read.

In this guide, you'll discover how to set up your Flipboard account and choose the topics that interest you most. You'll also learn how to customize your newsfeed by using the search bar and adding content to magazines. –NATE DRAKE



1 DOWNLOAD AND INSTALL

Open the Microsoft Store and type "Flipboard" into the top-right. Click "Get" to install the application [Image A], then press "Launch." Alternatively, you can sign up via the Flipboard website (https://flipboard.com). The website has more functionality than the app. Any changes you make are reflected both on the site and in the app itself.

2 THE BASICS

When you first enter Flipboard, you are asked to click tiles to reflect which categories you want to see on your home screen. Once you've done this, you need to either "Connect with Facebook" or sign up using your email account. Whichever method you use, you can select a unique Flipboard username during setup. The usual welcome email is sent, requesting you to confirm your registration. Once this has been completed, you are ready to start using Flipboard.

›› First link your social media to your Flipboard account. You can do this by clicking on the social media tiles shown on your main screen. Once you are signed in to the main page, just press "+" to begin adding content.

3 ORGANIZE THE HOME CAROUSEL

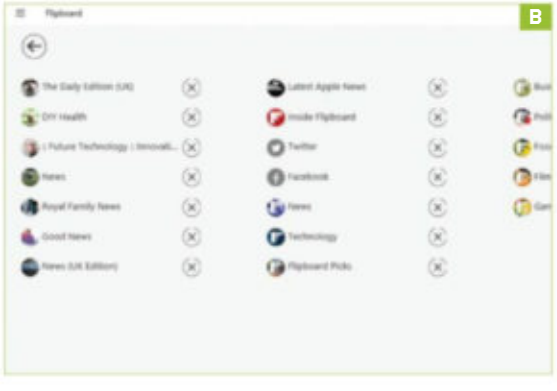
Your home screen initially only displays the categories you chose during signup. To add more content, click the search bar at the top-right. Enter the subject you want to search for—"Health," for example. Flipboard now displays a list of relevant content. Click the flag icon in each tile to add to your Home Carousel.

›› Options that appear on your Home Carousel can be changed at any time in the app or through your browser. In the app, click "Settings" at the top-right, then "App Commands." A pop-up menu appears along the bottom of the screen. From here you can go to your profile, sign out, refresh, or edit. Select "Edit." Just click the "X" beside any topic to remove it from your feed [Image B].

4 THE DAILY EDITION

The Daily Edition is a feature that enables you to catch up on all the news on one page. It updates daily at 7 a.m. and can be accessed in the app, but is best viewed via the Flipboard website. To get started, navigate to https://flipboard.com, then click the search bar at the top-right, and select "The Daily Edition."

›› As well as scrolling through your news for that day, you can share the Daily Edition with others. Click



the "Share Collection" button at the bottom-right of the page [Image C]. Enter the person's Flipboard username or email address to share directly, or you can share via social media.

›› Click "The News Desk" in the Daily Edition to access the News Desk main page. You can select "Follow" to include the News Desk on the list of highlights on your Home Carousel.

›› If you prefer to use the app, type "Daily Edition" into the search bar at the top-right of the screen. This then displays varying results for the Daily Edition in different locations.

5 SMART MAGAZINES

Smart Magazines form a core part of Flipboard. This feature blends all your favorite pieces, such as leading opinions, expert pieces, and recommended stories about a particular topic, into a single digital magazine. You choose a topic and select related content with the help of hashtags. All your choices are then collated and presented as a custom-made e-zine you can flip through.

›› On the webpage, go to "What's your passion" at the top of the screen. Click the topics that interest you most. These are added to the top of your homepage. Each topic you choose populates with the most up-to-date news information for that subject. You can customize it even further by clicking the "(...)" beside the topic name and selecting "Personalize." You can then choose subtopics to populate this magazine—for example, "World Trade Organization" in "World Economy."

6 FLIPBOARD EDITOR

The editor is an online web tool where you can create, edit, and manage any or all of the magazines you create. In the app, flick upward to scroll through your page. Each story you click into shows a "+" beside the heading. When you select the "+" a tab slides open from the right-hand side of the screen. It asks you to "Flip this into..." with the option to "Create New Magazine" underneath. You can then enter the name of your magazine, the description, and the category that it falls under. You can also uncheck the box if you don't want it to be viewed by everyone. You can create as many magazines as you want. Articles can be added to your magazine by clicking "+" then choosing the magazine you wish it to appear in, and finally selecting the check button on the bottom-right of the screen.

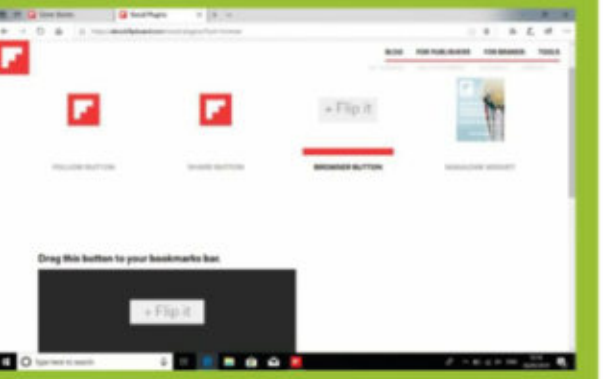
7 THE SEARCH BUTTON

The search button is your gateway to all things Flipboard. The search feature is available on both the Flipboard website and the app, but the web version has more options.

To get started, select the magnifying glass at the top-right of the webpage. A drop-down menu now appears [Image D], which displays a "Featured" section, with items such as "Agriculture," "Politics," and "#MagsWeLove." It's also where you can access the Daily Edition, along with an "Explore" section. When you click "Explore," topics ranging from "News" to "City Breaks" are displayed.

›› Entering a search term brings up a selection of results, which range from the "Top Result" to "Results of the Day," magazines covering this suggestion, or people who may be linked to this search topic.

FLIPBOARD BOOKMARKLET



You can further personalize your Flipboard newsfeed by using plugins. For instance, the Browser bookmarklet plugin can be used to "flip" articles you view in your web browser that you find interesting into magazines you've created. This is extremely useful for research, because you don't need to leave your web browser to collate content.

Navigate to https://about.flipboard.com/tools/. To install the Browser bookmarklet, scroll down to "Get Social Plugins." Select "Browser button," then drag the "+Flipit" button into your bookmarks.

From here, you will see plugins for "Follow" and "Share" buttons. There is also a handy Magazine widget, which you can choose to embed a thumbnail of your magazine on to your website or blog to share with others. If you are using Chrome, you can also add the Google Chrome Extension.

If you write website content yourself, such as a blog, consider installing the Share plugin. You can embed this in pages to make it easier for other Flipboard users to share your content. You can also add the Follow plugin to allow users to find and follow you on Flipboard more easily.

Discover Code Writer

YOU'LL NEED THIS

CODE WRITER
You can grab the app from the Microsoft Store.

ALTHOUGH MOST COMPETENT PROGRAMMERS can write code using anything from Microsoft Notepad to the back of an envelope, the majority of serious coders prefer to have a dedicated application for programming purposes.

Coder-friendly applications such as Code Writer are designed by programmers for programmers. This means that on first launch, you can automatically create code files with the correct extension, such as .html. The app also supports syntax highlighting and easy navigation of large files.

Code Writer isn't a fully-fledged IDE, and as such doesn't contain a built-in compiler or an easy way to automatically publish code to popular websites, such as GitHub. However, its stripped-down interface and bare-bones features mean that you can master the basics and streamline your coding in a matter of minutes.

In this guide, you'll discover how to create and edit simple files using Code Writer. You'll also learn how to harness the app's powerful Command Palette, which enables you to work with multiple files, search for specific terms, and automate tasks such as indenting multiple lines of code. Code Writer also supports keyboard shortcuts for virtually every command, enabling you to reach brutal levels of programming efficiency without using a mouse. –NATE DRAKE

A

1 SETUP

On first launch, Code Writer displays a handy overlay, explaining the basics of what each section does. This is shown once only, but don't fret too much, because the interface is very intuitive. To create a document, click "New" on the right-hand side of the screen. Code Writer now prompts you to choose a document type, such as HTML [Image A]. The code template is formatted with default headers and footers, so you can start coding right away. By default, code files are saved to your "Documents" folder. Click the "Save" button at the top-left, then "Save As" to choose a new file name and location.

2 HOW TO LOAD CODE

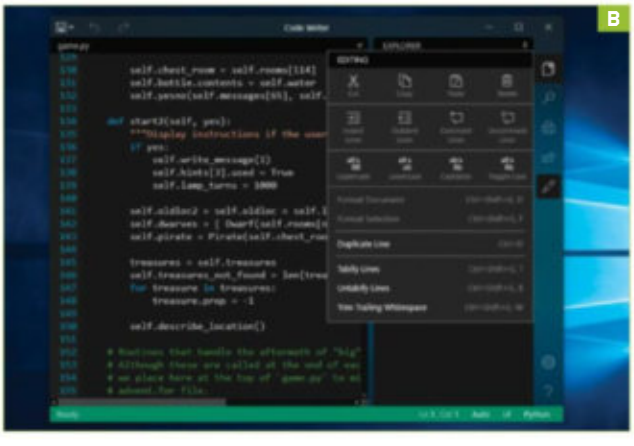
If you've created a new file using Code Writer, it opens automatically next time you launch the program. If you've already created other code files in a separate program, click the "Open" button at the top-right, and navigate to your file(s) of choice. If you open multiple files, you can switch between these by double-clicking the file name listed on the right of the screen. All changes to documents are auto-saved, so each time you reopen a file, it's exactly as you left it. Any files you saved yourself appear with a checkbox next to the file name. Code Writer places an "x" next to names of files it saved automatically.

3 EDITING YOUR CODE

Once your chosen files are open, editing your code is fairly straightforward. You can scroll, click, and alter text just as you would in Microsoft Notepad. If you have a large number of lines of code to work through, click the "Editing" button on the right-hand side of the page. This displays a handy collection of common commands [Image B]. Some of these, such as "Cut & Paste," are self-explanatory. Click a section and choose "Comment Lines" to annotate your code. To indent or outdent lines in a particular section, simply highlight it with your mouse, and click the corresponding button. If your code is case-sensitive, don't overlook the "Uppercase" and "Lowercase" options.

4 COMMAND PALETTE

The command palette is a quick and easy way to use Code Writer's features via the keyboard. You can launch it in a number of different modes, each of which carries out different functions. For instance, hold down Ctrl-P to launch the command palette in default mode. From here, you can easily search through all your code files and launch them. Hold down Ctrl-Shift-P for the palette's command mode; this contains a number of Code Writer's more advanced features [Image C]. For instance, select "Change File Types" to save code in a different format. You can also carry out surgical editing with the "Line," "Cut," and "Paste" functions. Whichever mode you choose, you can use the up and down arrows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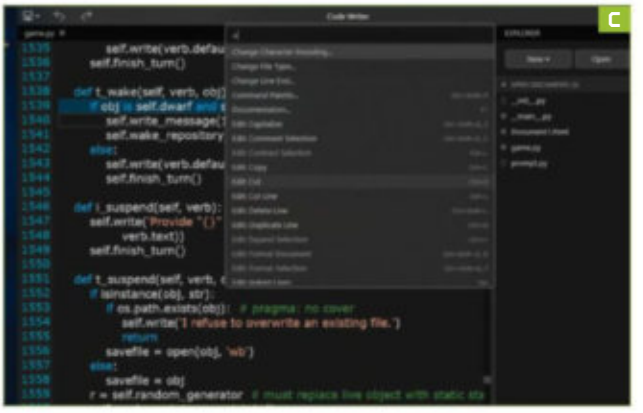


to switch between functions. Press Esc to dismiss the command palette altogether.

5 SEARCH AND REPLACE CODE

Code Writer has a simple but excellent search feature. To get started, click the "Search" button on the right-hand side to open the Find dialog. From here, you can enter your search term and click "Find Next" to start scanning your code. Pay close attention to the checkboxes, which allow you to match the case, whole words, and regular expressions.

›› To replace text, simply toggle the replace mode by clicking the arrow next to the search box. Fill in the fields marked "Find what" and "Replace with," then choose either "Replace Next" or "Replace All."

6 SHARE YOUR CODE

Code Writer has no built-in collaboration tools, nor can you automatically publish content to GitHub. You can, however, share code files via Mail, Microsoft OneNote, Skype, and a few other select apps. To use this feature, save the file on which you are currently working, then click the "Share" button on the right-hand side. From here, you can enter your contact name and select an app for sharing. Files are sent in the same format in which they are saved—HTML, for example.

7 THEME EDITOR

While most users appreciate Code Writer for its simple minimalistic interface, you can make some tweaks if you wish. Click "Settings" at the bottom-right of the screen to view the Editor preferences. Code Writer offers three themes: Dark (default), Light, and Obsidian. From here, you can also change the font type and text size [**Image D**]. This only affects the Code Writer interface, and doesn't change your code formatting. If you still have trouble navigating your code, enable "Current Line Highlighting" to easily track the line on which you are currently working.

KEYBOARD SHORTCUTS

The Code Writer team recognizes that most programmers are keyboard veterans, and may even have started coding before the advent of the computer mouse. For this reason, virtually every command in the application can be accessed via a keyboard shortcut. There's a comprehensive list of these available in the Code Writer documentation, which you can access by clicking the "?" at the bottom-right corner of the screen.

If you're keen to begin coding, we've listed a quick-start guide of some of the most useful keyboard commands below to get you started.

Ctrl-Tab: *Switch to the next document.*

Ctrl-Shift-E: *Open the Explorer sidebar.*

Back or Shift-Back: *Backspace.*

Ctrl-G: *Open the Command Palette in go-to line mode.*

Ctrl-Shift-G, D: *Format document.*

Ctrl-Right: *Move to the next word.*

Shift-Ctrl-Home: *Move to the start of the document.*

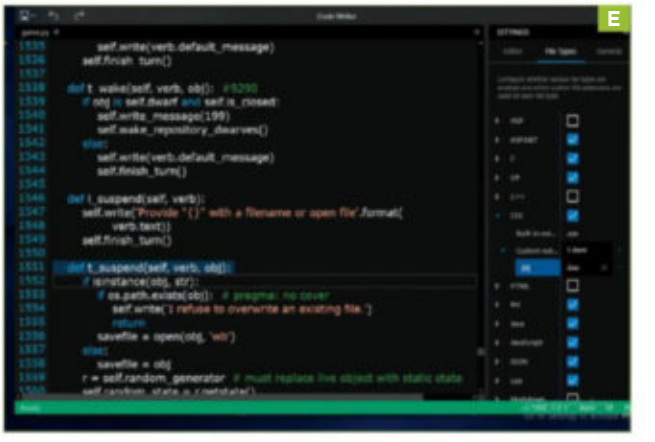
Ctrl-Shift-W: *Select the current word.*

Ctrl-Shift-U: *Make uppercase.*

8 CUSTOMIZE FILE TYPES

Code Writer supports a number of programming languages, but this can be truly overwhelming if you only use one or two. You may also wish to work with code files that aren't supported by default in the app.

›› To view supported code files, click the "Settings" button at the bottom-right, then select the "File Types" tab [**Image E**]. Uncheck the box next to any programming languages you don't use. In future, these won't be displayed as an option when you click to create new code. To add a custom file extension, click the "+" button while selecting a supported programming language. This creates a custom extension with a default name of .ext1. Click and type to edit the new file name and extension.



Stay Protected Online with Dashlane

YOU'LL NEED THIS

DASHLANE
Download the app from www.dashlane.com.

GIVEN THE NUMBER OF ONLINE SERVICES available today, it's very tempting to use the same password for each website. However, if hackers manage to break into one service, they'll be able to access your other accounts, too.

Password managers, such as Dashlane, offer a good compromise between security and convenience. They work by letting you choose a single master password to store all your login credentials in an encrypted database. Each time you visit your favorite website, Dashlane retrieves your password and fills in the login fields automatically. The app even includes a built-in strong password generator, enabling you to create individual secure passwords for all your online accounts.

In this guide, you'll discover how to install the Dashlane desktop client, as well as the dedicated Dashlane web extension, which loads login details into your browser. You'll also learn how to make Dashlane more secure by storing your password database locally, and protect your logins with two-factor authentication.

Dashlane comes with a free trial of its premium version, which allows you to sync your passwords across all your devices. After one month, you'll switch to the basic free version, which stores credentials only on your own machine. –NATE DRAKE

1 INSTALLATION

Navigate to www.dashlane.com. Select "Get Dashlane—it's free." You are then directed to a download page; choose the link labeled "For the Windows version click here." Choose "Run" to launch the Dashlane setup. Click "Create your free Account," then enter your email address and password. You'll use these credentials to sign in to Dashlane [**Image A**] from now on. Setup also prompts you to add Dashlane to your browser.

2 SET A SECURE MASTER PASSWORD

In the previous step, you created a password for your Dashlane account. This is known as your master password, because it's used to access all your other credentials. This means it should be unique, strong, and easy to remember. We recommend using Diceware (http://bit.ly/diceware) to create a high-entropy password. To update your master password, open the Dashlane app from the Start menu. Go to "Tools → Preferences." Select the "Account" tab. Click "Change" beside "Master Password," and enter the new password. Make sure you write your password down and keep it in a safe place.

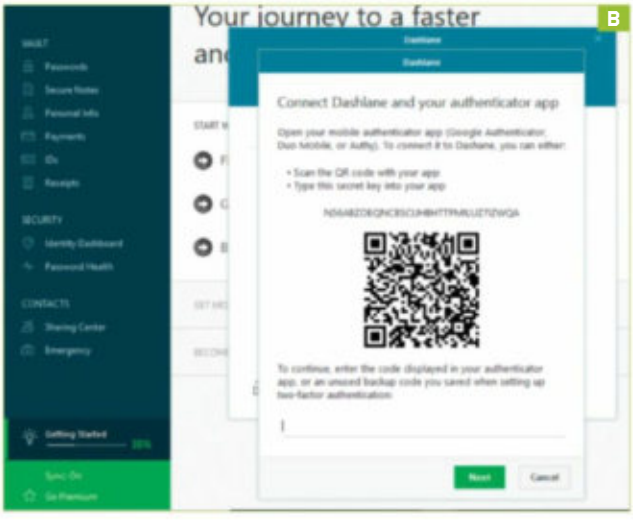
3 CHANGE SYNC PREFERENCES

The Dashlane app comes with a free one-month trial of its premium version. This means your login credentials are synched across all your devices via Dashlane's servers. This is very convenient, but if Dashlane's computers are ever compromised, your details will be at risk. After one month, Dashlane reverts to the basic free version, which stores passwords locally on your machine in an encrypted database. This is much more secure, as your credentials never leave your device. To change your sync preferences, open Dashlane, go to "Sync → Open Sync Preferences," then deselect "Sync between my devices."

4 TWO-FACTOR AUTHENTICATION

Two-factor authentication (2FA) is a great way to secure access to your Dashlane account. Each time anyone tries to sign in to Dashlane from a new device, they need to enter a six-digit code as well as your master password.

» To enable 2FA, go to "Tools → Preferences → Security," then click the "Two-factor Authentication"



tab. Switch "Two-factor authentication" to "On," then click "Next." In order to continue, you must have an OTP authentication app on your device, such as Google Authenticator. Choose "Next" to proceed. Scan the QR code using your OTP app [Image B], then enter the six-digit code, and select "Next." Dashlane prompts you to enter a backup cell phone number as an alternative way to receive codes. Enter this, then press "Next." Once 2FA setup is complete, Dashlane displays a small list of emergency codes you can use to log in if you lose access to your mobile device. Write these down and put them in a safe place.

5 SAVE YOUR PASSWORDS

Visit a website you use and choose to sign in. Once you've entered your credentials, a Dashlane pop-up appears, asking if you wish to save your login details. If you do this, from now on, when you visit this site, your username and password load automatically. If you're creating an online account for the first time, consider using Dashlane's password generator. You can access this via the Dashlane web extension icon. Repeat these steps for all your online accounts. If you're registering a new account, Dashlane can create a secure password for you. Just choose "Generate strong password" in the password field.

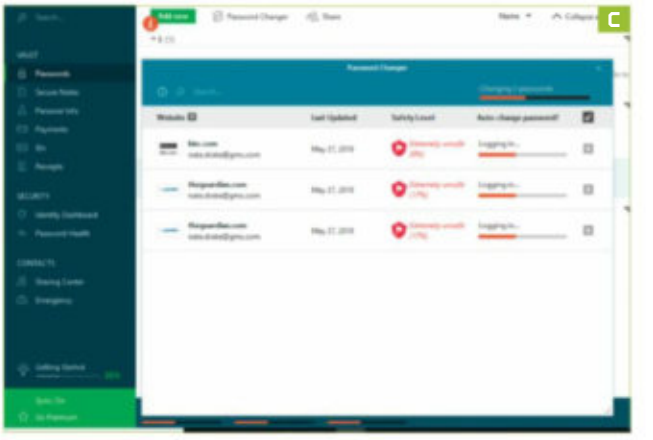
6 MANAGE YOUR CREDENTIALS

Dashlane has a built-in Password Changer [Image C], which is compatible with a number of online services. This is a quick and easy way to change your existing passwords to stronger, randomly generated ones. To get started, open Dashlane and select "Passwords" on the left-hand side, then go to "Password Changer" at the top. You can choose to change all passwords at once or you can auto change them individually. Just click the checkbox beside "Auto change password." Select the green "Change all passwords" button at the top of the screen. Dashlane logs into each of your accounts and attempts to change your passwords. If your online account isn't compatible with Password Changer, you can still use Dashlane's built-in password generator to change your login details manually. Launch the password generator via the Dashlane web browser.

7 SECURE NOTES

The Secure Notes feature allows you to store private keys to software, Wi-Fi passwords, and any other documents you need to store securely and access easily.

›› To create a Secure Note, open Dashlane, choose "Secure Notes" on the left-hand side, then click the "Add New" button at the top-left. This opens up a note editor. You can enter a title for your note along with the body. This can be as large as you see fit. You can also securely store a file by attaching one to your note. Click "Attach File" to do so. Select "OK" to save your new Secure Note. Dashlane has ready-made templates for certain credentials, such as Wi-Fi passwords. You can choose to use these each time you click "Add New."



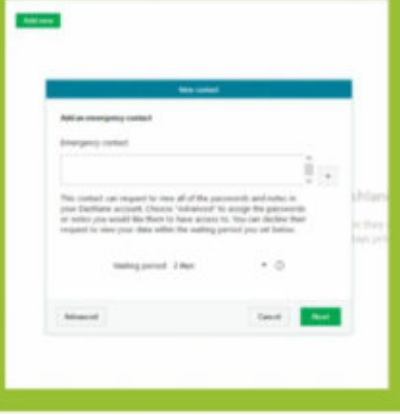
8 IN CASE YOU ARE LOCKED OUT

Dashlane claims that it never stores your master password on its servers. This means that your credentials are safer, but if you've forgotten your master password, you may not be able to recover your data.

›› If you think that you might have forgotten your master password, but have previously followed the steps in the boxout below to create an emergency contact, you can ask your contact to follow the steps at http://bit.ly/2Wofp32 to request access to your credentials. Be aware that there's a mandatory waiting period for this, depending on the settings you chose when creating your emergency contact.

›› If you know your master password but have lost the mobile device you use for two-factor authentication, enter one of the emergency backup codes you wrote down during setup to access your account. Alternatively, you can choose to receive a security code via SMS to your alternate cell phone number.

EMERGENCY CONTACT



If you're worried that you could lose access to Dashlane, you can ask another Dashlane user to be your emergency contact.

Open Dashlane, go to "Emergency → Add New," and enter the email address of your emergency contact in the box marked "New Contact." By default, your emergency contact can access all your login credentials, so click "Advanced" to share only some of your passwords. Dashlane also sets a waiting time (the default is two days) after which your emergency contact can access your data. You can change this if you wish via the drop-down menu. Click "Next," fill out the message to your emergency contact, then press "Send." Ask your contact to open their email and click the link marked "Get emergency access." If they need access to your Dashlane, tell them to open the app and go to the "Emergency" section. If they click the key next to your email address, you will receive an email with a link explaining that your emergency contact has requested access. Visit http://bit.ly/2Wofp32 for a full rundown of the emergency contact options.

Create VCR-Style Glitch Effects

YOU'LL NEED THIS

PHOTOSHOP CC
Subscribe to a suitable package at www.adobe.com (other image editors can produce similar effects).

THE AVERAGE AGE OF THE READERS of this magazine is such that we don't need to explain what a VHS player or VCR was, thankfully, but this ancient technology has been consigned to the trash can of history, along with the eight-track cartridge and the wax cylinder.

What the VHS system did have, as with many analog technologies, was charm—especially when it started to go wrong. The glitches, picture wobbles, and color artifacts this generates are a kind of art in their own way, perhaps explaining their continued popularity in movies and TV shows. Any time a computer fails or is hacked, or someone's reviewing CCTV footage, you can guarantee there will be some sort of VHS effect, even if it's being recorded on Blu-ray.

The association of this kind of effect with crime or horror means it's easy to add a cinematic look this way, especially in conjunction with a noise filter. It also gives a cool '80s aesthetic, if that's what you're after. We're working in Photoshop CC here, but you could do something very similar in Elements, GIMP, or Affinity Photo. –IAN EVENDEN

A


B

1 CHOOSE A PHOTO

One of the good things about this effect is that it's appropriate for almost any image. After all, what's been captured with a DSLR could also have been shot using a scratchy CCTV camera. Look, for example, at these definitely very real business people, discussing whatever it is on that piece of paper. Secrets! That's what's on it. And our image has been filmed by a tiny spy camera, dropped by an agent into the office of *Maximum PC's* greatest corporate rivals. Better glitch it up.

2 ADD SOME TEXT

The first signifier that you're looking at tape-recorded footage is the information the recorder burns into the image. This can range from the time and date, to an index number, to the word "record"—in case that wasn't already clear. There are VCR-specific fonts available online if you want to install one, but you can create your own using just about any monospaced font (one in which every character occupies the same amount of horizontal space). We're using Source Code Pro from Adobe Typekit, but others are available. Choose a light color—white or light gray—and write what you want, initially quite small. Turn off antialiasing, and rasterize the type layer by right-clicking its entry in the Layers palette and finding the option in the menu. Now, with the layer still selected, choose "Edit → Free Transform," and make the text bigger by dragging one of the corners. As it grows, you'll see it pixelate. Make it a bit too big, apply the transformation, and double-click the layer to open the Layer Styles window. Put a check in the "Stroke" box, and your text gains an outline [Image A]. Now Free Transform again, but the other way, shrinking it so the size looks right. When you're happy, group your type layers so you can easily find them later, and move them to the top of the stack if they're not already.

3 SMART OBJECT

Convert your background layer into a Smart Object by right-clicking it and choosing the option. The benefit of this is that you're able to apply filters and effects to a Smart Object non-destructively, coming back later to edit them. Duplicate the new Object, and leave the original at the bottom of the stack— we'll be duplicating it again later.


C


D


F

4 SHEAR GENIUS

One of the features of poor-quality VHS is the way the colors don't quite blend together properly. It's similar to the chromatic aberration seen from wide-aperture camera lenses, when different wavelengths of light aren't brought to precisely the same point of focus. Select the top-most layer that isn't the text, and open the Shear filter from "Filter → Distort." This provides a line you can drag to bend your image from left to right, with the option of it wrapping around (the "Repeat Edge Pixels" box, which we've left unchecked). We don't want too much of a bend, so have made a meandering line with points that only go around halfway across the grid squares. Hit "OK," and check the effect by toggling the top layer on and off using the eye icon.

5 ADVANCED BLENDING

To get the color glitch, you need to open the Layer Styles window for the layer you just used Shear on. Double-click the layer, and under "Blending Options" you'll find "Advanced Blending," with "R," "G," and "B" boxes to represent the three colors being mixed to provide the full color image. Unchecking one of these prevents that color from blending—so uncheck the "R" and "G," and see what happens. If, like us, you went a bit too far with the Shear filter, you can edit it by double-clicking its entry under Smart Filters. The Shear workspace is annoyingly small, so it may take some precision mouse work [**Image B**].

6 MORE LAYERS

Rename that layer B, as that's the only active channel, then duplicate your original layer two more times. One of these will be R, the other G. Repeat the Shear effect on them—it has to be a slightly different adjustment on each layer, otherwise they blend back together perfectly—and use "Advanced Blending" to leave one with the R channel, and the other with the G channel.

7 BLUR AND DISTORT

Create another duplicate of your original layer and move it almost to the top of the stack, just below the text layer. Open Shear again, and create a heavy distortion [**Image C**]. Staying on this layer, click the "Add Layer Mask" icon at the bottom of the palette and, using the Rectangular Marquee tool, create a narrow band across the full width of the image near the top, and fill it with black using the Bucket tool.


E

8 MORE MASKS

It doesn't fill with black, but creates a hole through which the layer below, which hasn't been distorted as much, shows through. Create more such masks, using the same method, of differing heights but always full width. This is one of those tasks where learning the keyboard shortcuts—M and G—saves time. We've edited the Shear filter, because it was too strong, and added a Gaussian Blur filter to this layer, too [**Image D**].

9 SCAN LINES

Finally, add some old-school NTSC realism by putting scan lines over the image. Use the "New Layer" button at the bottom of the palette to add a Pattern layer, and position it at the top, above the text. When the pattern options appear, choose the second one from the left—horizontal lines. This covers the image [**Image E**], so blend it back in by changing the Blend Mode to "Multiply," and the Opacity to around 25%.

10 BRING BACK THE TEXT

Unhide the text layer using the eye icon to its left, and the final glitched image is revealed [**Image F**]. We may not be able to read the secrets they're discussing—our tiny spy camera isn't good enough—but we'll send an agent to photograph it on to microfilm.

LIKE OBJECTS, BUT SMARTER

Smart Objects preserve the source file's contents, using it as a reference, which means you can mess around with it all you like without actually losing any data. For example, you could shrink a Smart Object, then later make it bigger again without a loss in quality. This isn't too much of a consideration here, where we're setting out to ruin an image, but it can save a lot of work on composition where you unexpectedly need to alter a layer you thought was finished with. Creating Smart Objects makes your files bigger, but it's good practice to create them nonetheless. Storage is cheap, graphic designers' time is expensive.

Automate Tasks in Windows

YOU'LL NEED THIS

WINDOWS
Windows 7, 8.1, and 10 all support this feature.

WINDOWS' TASK SCHEDULER is something of an arcane tool. It's been around since the Microsoft Plus! add-on pack for Windows 95. It's also an app that's in a state of flux. Two of its options—the ability to send an email and to display a message on screen—have been deprecated since Windows 8.1. They still appear in the app, though, and they're still there in the latest preview build that Microsoft recently pushed out to Windows Insiders. They just don't work. This suggests Task Scheduler is in need of an overhaul, but it's a low priority for Microsoft, otherwise it wouldn't have languished in this state.

What's left of it works well, though, enabling you to trigger the launch of programs at specific times, or specify other events that will set them off. And it's interesting what you can still do—"programs" covers a lot of things. **–IAN EVENDEN**

1 OPEN THE TASK SCHEDULER

Pop up the "Start" menu and begin typing "Task" to find the Task Scheduler. It's rarely the top result, but it is there. You can also find it under "Windows Administrative Tools" in the alphabetized list ("Accessories → System Tools" in Windows 7), or in the Control Panel under "Administrative Tasks," or you can type "taskschd.msc" into a "Run" window [Image A].

2 MAKE A FOLDER

Once the Scheduler's open, you'll see the Task Scheduler Library on the left, probably with a single folder in it—"Microsoft." These are the tasks created by the system. Ours has two folders, as we're using our gaming PC. Create a folder to keep your tasks in one place: Right-click the Library, and choose "New Folder." Give it a name, and click "OK" [Image B].

3 CREATE A TASK

With the new folder selected, right-click it and choose "Create Basic Task," or use "Action → Create Basic Task." This opens a wizard that streamlines the process, but lacks some of the fine control of the "Create Task" approach. When the wizard opens, give your task a name and a description—if you're creating a lot of tasks, be as verbose as you can [Image C].

4 CHOOSE A TRIGGER

Triggers tell the Scheduler when to activate tasks. They can be a time, an event, or a more specific event from a complex list. We want ours to trigger weekly, so choose that, followed by a start date, a recurrence interval (one week), a day (Friday), and a time (17:01). If you're deploying a task to a lot of PCs, you can even sync them across time zones, so globetrotters don't miss out [Image D].

5 SELECT A TASK

The "Basic Task" wizard really only has one option for what tasks can be: "Start a program." There are two other options—"Send an email" and "Display a message"—but they're deprecated, and probably won't be there much longer. Luckily, Windows 10 considers lots of things programs, such as shutting down or restarting the PC. Click "Browse" to choose one.

6 PICK A PROGRAM

By default, the File Explorer window that appears shows the System32 folder—a Windows folder that's full of subfolders and mysterious EXE and DLL files. It helps to know what you're looking for, so you can search for it, rather than scroll through the items. We want logoff.exe, which does what you'd expect, with no warning. Click "Next," then "Finish" to complete the process [Image E].

7 TASK PROPERTIES

Your task has an associated Properties window (accessible by right-clicking the task on the left). In this window, you can set which users are affected by the task. You can edit the name and descriptions, too, and all the data ascribed to the task, such as the trigger. You can take it further, specifying whether the PC needs to be plugged in, or idle, for the task to start [Image F].

8 DISPLAY A MESSAGE

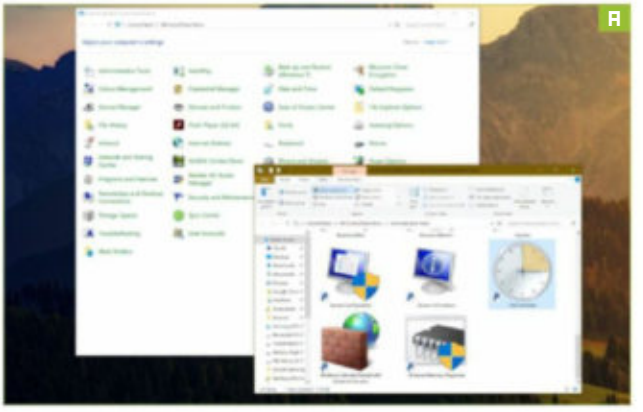
The logoff task we've created occurs without warning, no matter what you're doing, and whether you've saved your work or not. It would be polite, therefore, to warn the user of what's about to happen. Message sending is deprecated, however—it's still there but it doesn't work, throwing up a cryptic error message. As a workaround, use an option that does work: running a program [Image G].

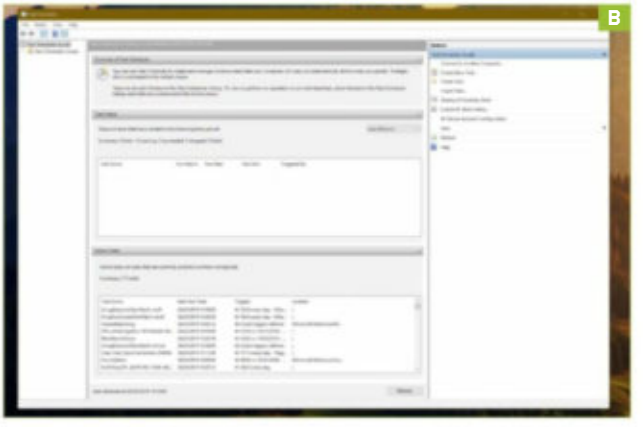
9 MESSAGE WORKAROUND

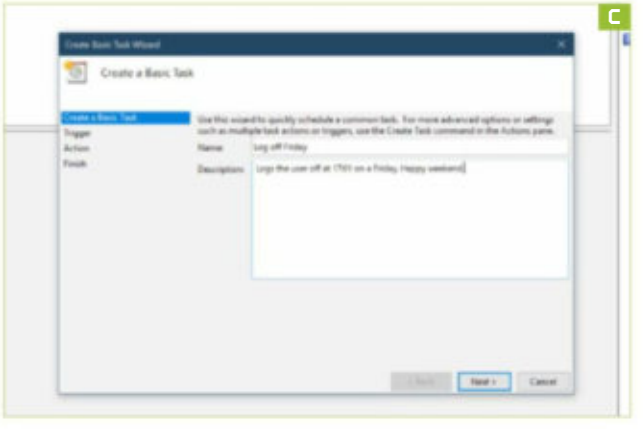
Create a new Basic Task, and set it to run five minutes before the logoff task every Friday. There's an app in System32 called msg.exe, which displays a message on the screen. Choose it and type your message in the "Add Arguments" box, preceded by a "*" and a space, so something along the lines of: "* Log off and go home." At the trigger time, your message appears in the middle of the screen.

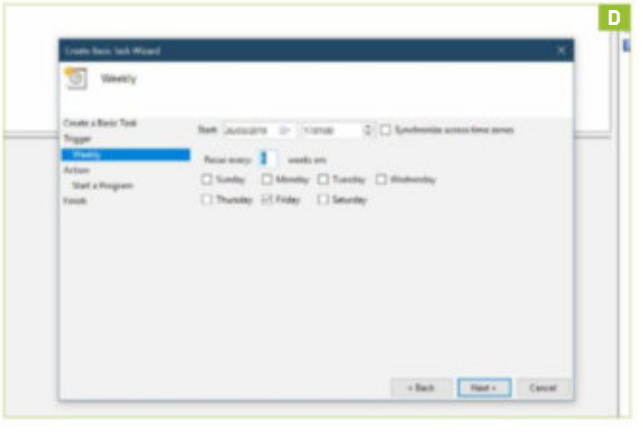
10 DELETE A TASK

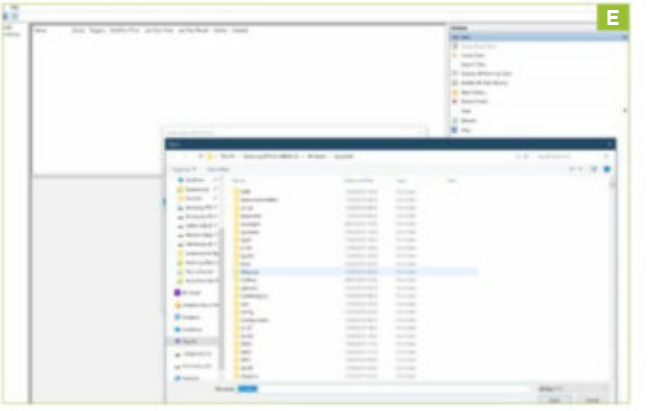
To stop a task from running, you can either disable it or delete it. Both can be achieved through the right-click menu in the Scheduler window—click the task you want to stop, then choose either "Disable" or "Delete" from the right-click menu. Choose "Disable" and the task's status changes in the list. To delete it, you're asked if you're sure. Click "Yes" and it's gone forever [Image H].

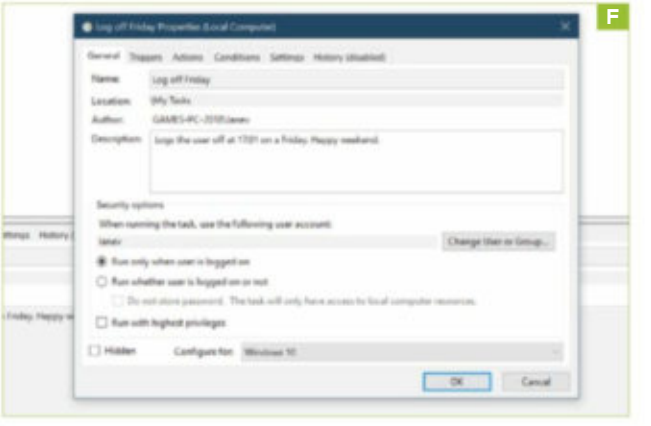


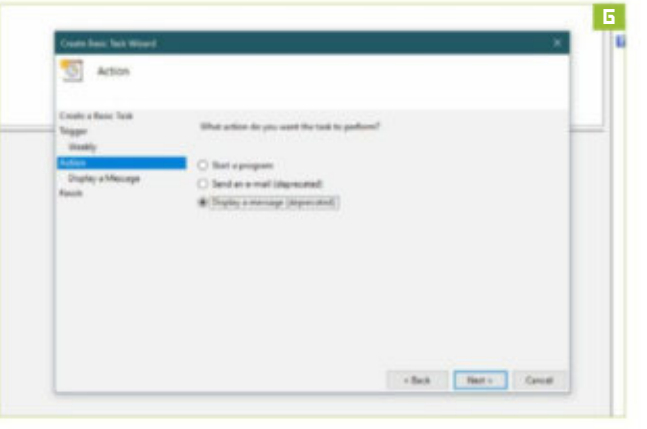


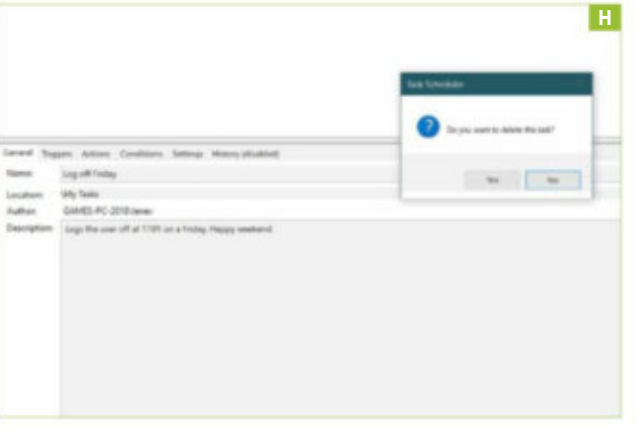












BUILD IT

ALAN DEXTER, EXECUTIVE EDITOR

Cooking Up a Gamer's Delight

Take the most powerful mainstream graphics card around, add high-end hardware and a little RGB, and bake at 4K

LENGTH OF TIME: **3-4 HOURS**

LEVEL OF DIFFICULTY: MEDIUM

THE CONCEPT

THE BUILD FOR THIS month's cover feature is laser-focused on value for money, and seeing what you can do on an incredibly tight budget. This build is the counterpoint to that. We barely looked at the price tag during its construction, and didn't pay much heed to it when we did add it all up. We did, of course, have a pretty good idea what the best value components were, and what sort of ballpark we were going to end up playing in, but on the whole, money wasn't a factor. No, this machine was all about one thing: performance.

Specifically, we wanted to build a machine that wouldn't be constrained by bottlenecks. From the off, we wanted to give the Asus GeForce RTX 2080 Ti ROG Strix Gaming OC room to strut its stuff, and once you've got a serious bit of silicon like that in your machine, lots of the other components fall into place. The big selling point of this graphics card, and the GPU that powers it, is that it makes the dream of 4K gaming a reality. Yes, even at the highest settings (although there's an important caveat when it comes to RTX titles: Even this card struggles to maintain 60fps at ultimate settings). Which means that while we generally don't include screen recommendations on these pages, we'll make an exception, and suggest that this rig is ideally paired with a quality 4K monitor, something like the ViewSonic VP3268-4K.

So, over the next few pages, we show you how to build the sort of machine that dreams are made of. Maybe not *Maximum PC* "Dream Machine" dreams, but not as far off as you might imagine. Let's see what spending nearly 10 times the cost of our budget build nets you....

A FACTOR OF PERFORMANCE

AS WE'VE SAID, we're not particularly concerned about costs with this build, which gives us plenty of scope when it comes to picking the individual components. We wanted to make sure that we weren't holding the GPU back, so enlisted the help of the Core i9-9900K for the main grunt work. Until we see how Ryzen 3000-series CPUs actually perform, this is the go-to option in the mainstream space for performance junkies. The Core i9-9900K was still locked under a waterblock in our Dream Machine 2019, unfortunately, so in order to use it here, we had to strip down that beast, which involved a fair amount of foul language, a reasonable number of spillages, plenty of scratches and bruises, and bright red hands at the end of it all.

With the GPU and CPU selected, the choice of motherboard went to MSI's MPG Z390 Gaming Edge AC, because it was fresh in the office for review, and in terms of memory, we went for 32GB of HyperX Predator DDR4-3000 RAM—this should be more than enough for what we've got in mind for this build. Storage-wise, we've gone for a speedy 1TB 970 Evo M.2 drive, which is fast without being prohibitively expensive. We've paired that with 12TB of spinning platter storage, giving us plenty of space for work and play.

When you've got such great hardware beating away at the heart of the machine, it makes sense to show it off, which is why we turned to the new Define S2 Vision RGB from Fractal Design. This is a vibrant and spacious case, with plenty of support for cooling options, which is good, because we're also using the Corsair Hydro H115i Pro all-in-one. It's is a hefty piece of cooling, but we had some interesting plans for how to install it. So, let's get building....

INGREDIENTS

PART		STREET PRICE
Case	Fractal Design Define S2 Vision	$250
Motherboard	MSI MPG Z390 Gaming Edge AC ATX	$180
CPU	Intel Core i9-9900K	$485
CPU Cooler	Corsair Hydro Series H115i Pro RGB 280mm	$130
GPU	Asus GeForce RTX 2080 Ti ROG Strix Gaming OC	$1,270
Memory	HyperX Predator 32GB (2x 16GB) DDR4-3000	$205
PSU	Corsair HX1200i 1200W	$220
OS Storage	Samsung 970 Evo 1TB M.2-2280	$215
Data Storage	Seagate IronWolf 12TB	$345
OS	Windows 10 64-bit OEM	$100
Total		$3,400

1 START WITH THE BASICS

TO MAKE SURE that the core components were working, we slotted the CPU into the motherboard, connected the cooler, added the RAM and M.2 SSD, then connected the power, with it all on top of the mobo box. We hooked up a screen, then shorted the two pins on the front panel block that normally connect to the power button. This core was detected, and it booted without fuss. It's worth holding the cooler so air can flow freely through it. Once done, we disconnected the power supply and cooler, and started prepping the case. The smoked-glass side panels pop off once the thumbscrews have been removed, while a button at the top of the back panel releases the glass panel roof. We could remove the PSU shroud as well, but didn't feel this was necessary for what we had in mind.

2 INSTALL THE MOTHERBOARD

THE DEFINE S2 VISION'S main chamber offers little in the way of resistance to installing a motherboard, but the PSU shroud made things feel tight on the bottom edge. Maybe we should have removed it after all. Don't forget to slide the I/O plate into place before putting the motherboard in, and ensure the clips sit on top of the ports, not in them—which is what happened to us. Luckily, we spotted this before turning it on, so managed to avoid causing damage to the ports. With the motherboard and plate in place, it's simply a case of screwing in the eight screws that hold the board in position. We don't usually connect the case cables at this stage, but things were so tight at the bottom of the case that we felt we needed to do so here before adding even more cables to the mix.

3 PLAN TO BE COOL

THE DEFINE S2 VISION supports a variety of cooling solutions, so we were spoilt for choice when mounting the Corsair H115i Pro. Its radiator is big, as it supports twin 140mm fans, and working out the best place to hold it was tricky. One option was to mount it facing outward on the right of the mobo tray, but that didn't provide optimal airflow. Another option was to install it in the roof, but we found it a bit too close to our memory sticks for comfort. Our solution was to place the radiator behind the fans at the front. One problem was that we couldn't install all three fans and the radiator, but it still provided sufficient airflow, especially with the rear fan drawing air across the mobo and components. We had to remove the existing fans from the radiator first—easily done.

4 AN EXTRA PAIR

TRYING TO HOLD a radiator in place while screwing a fan into that radiator is tricky without an extra pair of hands. Actually, it was only a problem for the first screw, as after that, we could subtly move the radiator, or fan, or both, to make sure everything lined up. Connect the top-left screw first, then bottom-right, top-right, before finishing with bottom-left. Once the second fan was installed, we could look at the wiring. The fans in the Define S2 Vision are all PWM fans, so we could plug the front two into the controller for the H115i Pro. We didn't need the controller installed by default in the back of the case—it was easy to remove, and meant there were fewer cables to deal with. All these fans are ARGB units, so we installed the Adjust R1 controller, giving access to lots of fancy light patterns.

5 LIGHT AND POWER

WE'D ALREADY REMOVED the two graphics card blanking plates, but if you haven't, do so now. Slide the card into the top expansion slot, and make sure the retention clip flicks into place as it hits the bottom. Secure it in place with the thumbscrews. Installing the PSU is trickier, which again had us wondering if we should have removed the shroud. This is a modular PSU, so connect the cables you need before installing; adding more after involves trying to plug in cables by touch alone. If you've got a similar loadout as we have, a single drive power cable, two PCIe cables, and the 12V CPU connectors are all that's needed. Screw the bracket on to your PSU, slide it in, and hold it in place with the thumbscrews. Feed the cables as best you can to where they're needed.

6 NEAT AND TIDY

THE LAST ITEM TO INSTALL is the hard drive. There are three caddies; for cable management reasons, we went for the bottom one. Cable management isn't much fun here, as there isn't a lot of room. We like wrapped columns of cables, but the space available meant they needed to be flattened. We stripped away as many cables as we could, but there are still a lot to take care of, as the front panel has USB 3.0 type-A and type-C ports, as well as a couple of USB 2.0 ports, and the audio cables. We could have spent more time sorting out the cabling, but the ARGB connector came undone surprisingly easily when moving things around—there are only so many times you can open up the case again because the lights aren't working correctly before you lose the plot.

1 **We could have installed the all-in-one's radiator in a few positions, but it worked well at the front of the case. Under load, we saw the temperatures rise to around 60 C, which isn't too bad. We had the option to attach the original fans behind the radiator as well, but didn't feel the need to without overclocking.**

2 **The PSU shroud at the bottom of the case produces a neat final build, but it does make for some frustrating times when actually piecing it together, particularly when it comes to attaching the front panel cables at the bottom of the motherboard. You can remove this shroud at the start of the build for an easier life.**

3 **While we're happy with the cabling on this side of the build, the back of the machine isn't quite so pretty. The space behind the motherboard tray is tight, and routing all the cables neatly felt like a Herculean task.**

POWER TO SPARE

WE MAY NOT have been concerned about the cost of this rig when we were piecing it together, but now it's whirring away, that $3,400 certainly makes its presence felt. At nearly 10 times the price of this month's cover build, an obvious question would be: Are you getting 10 times the performance? The short answer is yes, the longer answer is that it depends on what you're doing. Or more importantly, how you're doing it. We've benchmarked our budget star at 1080p, and played games at 720p to see if it can actually game, while this machine struts its stuff at full 4K, with everything turned up as high as it will go. It's hardly a fair comparison.

Some more relevant figures are born out of comparing this machine to the 4K zero-point, which we built just over a year ago. The zero-point cost a bit more than this rig when it was pieced together, but you may be able to pick up the parts for less today. Still, it's stood the test of time well—something that tends to be true at the top of the hardware pile (far more than at the budget end).

The key takeaway is that while we've had plenty of impressive advances over the last year, the same sort of money still nets you the kind of kick-ass machine that dreams are made of. You're looking at a machine that can handle the best games around with ease, and produce the kind of experiences that games developers want you to enjoy. It isn't all flawless, though, and *Tom Clancy's Ghost Recon: Wildlands* continues to be a thorn in the 2080 Ti's side, keeping it off the magical 60fps mark at the highest settings—if you want silky smooth performance, you have to fiddle with settings. That's also true if you want to strut your stuff with any ray-tracing titles. They still look better than anything you could produce with a more mainstream machine, but it's a bit galling to drop this much cash on a rig and not just be able to play it smoothly at the highest settings.

As ever at this stage in the build, we have to ask if there's anything we would change if we were to embark on such a system again, and the answer is more emphatic than it usually is: No, not really. The case was a challenge to work with, but this was partly due to the fact that we didn't remove the PSU shroud at the beginning; if we had, the chassis would have felt much more open to work in. It would have been nice to have a few more options with the cable management in the rear, but not enough to make us want to use another case. Ultimately, we were happy with the build and how the final machine looked. It's not a bad performer either.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	2,178	2,016 (-7%)
CrystalDisk QD32 Sequential Read (MB/s)	3,136	3,560 (14%)
CrystalDisk QD32 Sequential Write (MB/s)	2,126	2,510 (18%)
Rise of the Tomb Raider (fps)	68	84 (24%)
Total War: Warhammer II (fps)	42	57 (36%)
Tom Clancy's Ghost Recon: Wildlands (fps)	38	49 (29%)
3DMark: Fire Strike (Index)	6,988	8,357 (20%)

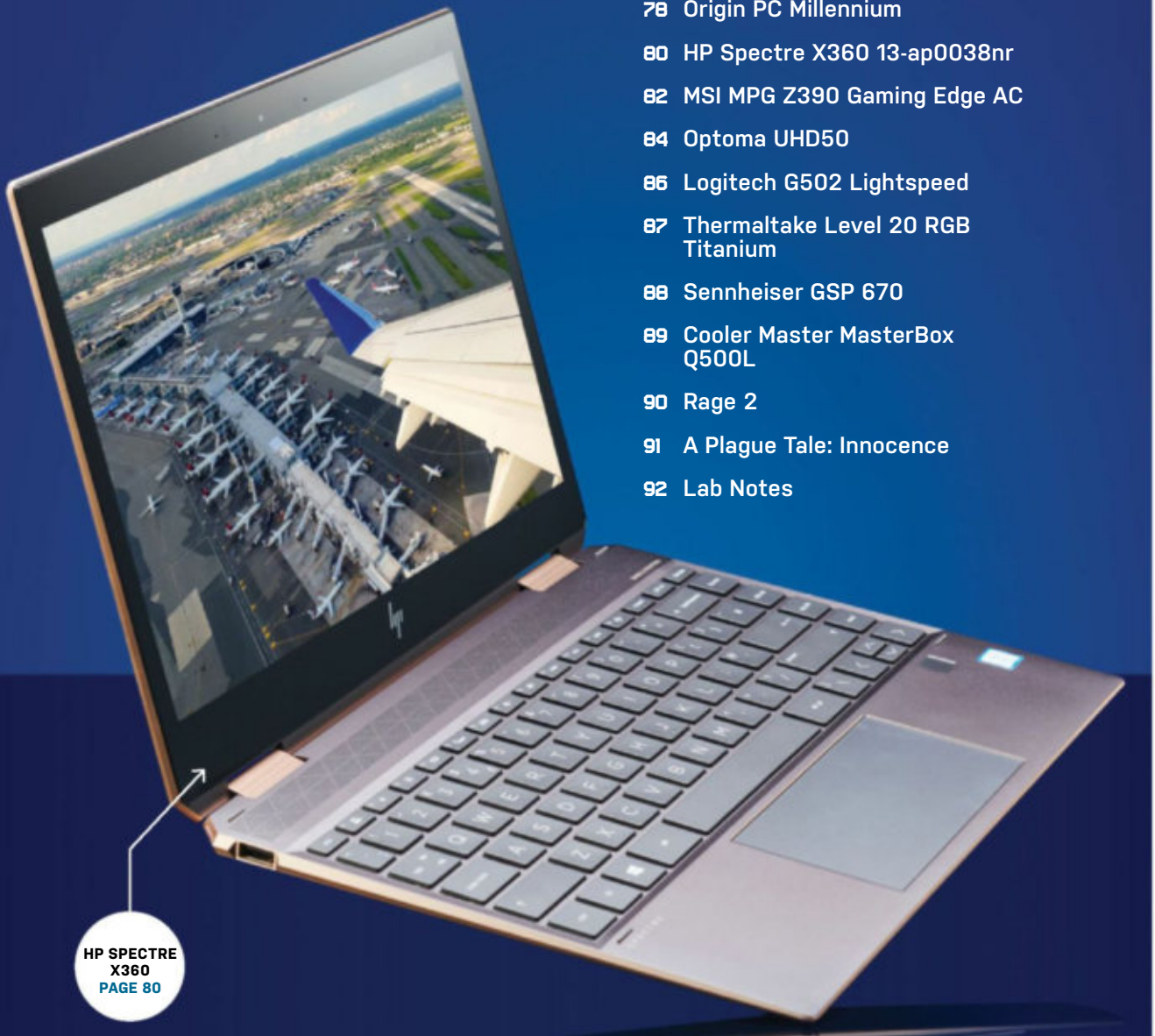
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an Intel Core i9-7900X, 32GB G.Skill RipJaws V series DDR4 @ 3,000, an MSI GeForce GTX 1080 Ti Gaming X, and a 512GB Samsung 960 Pro PCIe SSD. All tests performed at 4K at the highest graphical profile.

REVIEWS

TESTED. REVIEWED. VERDICTIZED.

INSIDE



HP SPECTRE X360
PAGE 80

Origin PC Millennium

An overabundance of drive bays, customization options, and general beastliness

ORIGIN PC'S MILLENNIUM gaming rig has a ridiculous number of drive bays and other features that can take it to workstation-class levels—four horizontal bays for optical drives or extra USB ports, and five optional hot-swappable hard drive bays below. These have an interesting access mechanism: Pull up on the top lever of the bay cover, then pull down to reveal the hard drive; pull far enough, and the hard drive pops out. The aluminum door can be adjusted to open from either side, too.

The case also has two hinged tempered glass side panels that attach to the chassis with magnets, so accessing the interior on either side is easy. The unit we received also has a custom printed panel on one side, with Origin's Vice logo, inspired by Miami, FL, in the '80s, with white RGB components set to match the blue and pink color scheme of the logo.

There are four configurations for GPU mounting that include standard horizontal and vertical, and inverted vertical and horizontal. If you elect for the GPUs to be mounted vertically, it puts the backplate on top of the case. In such instances, the backplate is hidden by a ventilated plastic cover, with a channel in the back to neatly run cables to the GPUs and the rest of the motherboard ports.

But this case is massive hunk of hardware at 22.5 x 8.5 x 23.5 inches—too big for a regular gaming PC. There isn't much of a reason to have all those extra bays either, as the model we received has a 500GB Samsung 970 Evo Plus and a 3TB HDD. That's more than enough space for normal work. But it's the dual RTX 2080 Ti GPUs that are the cornerstone of this entire rig—overkill for casual gaming, but if you want 4K, ultra graphics, and more than 60fps with ray tracing turned on, dual GPUs are necessary.

PLAYING BY NUMBERS

In our benchmarks, the Millennium churned out 37,148 at 1080p, 26,322 at 1440p, and 16,104 at 4K in 3D Mark. The Port Royal ray-tracing benchmark spat out 17,545 at 1080p, or 81fps. Our in-game benchmarks at 1080p on ultra got a little strange when it came to one of the games. In *Total War: Warhammer II*, frame rates averaged between 99 and 142 across battle, campaign, and skaven modes, while *Rise of the Tomb Raider* ran a consistent 143fps. *Metro Exodus* clocked an average of between 65 and 85fps with ray tracing turned on. But in *Ghost Recon: Wildlands*, the average fps dropped between eight and ten after each pass, with a high of 98fps and a low of 80fps. The results were similar after a second pass of four runs, waiting five minutes between runs, except for the first two. Between the first and second run, the fps dropped from 92 to 81, but waiting between the next two yielded 87 and 86fps. Current lack of proper SLI support doesn't explain the frame-rate drops in back-to-back benchmarks.

Both GPUs hit a peak of 88 C, according to EVGA Precision X1, which came preinstalled on the machine. Judging by settings, both GPUs came overclocked, which explains the high temperature. However, after resetting everything to default, the scaling issue was still present.

Strange benchmark issues aside, the Origin Millennium is still an attention-grabbing machine. But for those who just want to game, all those extra drive bays will most likely remain empty. For someone looking for a gaming PC that doubles as a workstation, there isn't a lot of fan space nor intake ventilation, which is important for any machine running some serious hardware. The Achilles heel in this otherwise great build is the chassis and some SLI scaling issues, depending on the game. **–JOANNA NELIUS**

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,152	2,055 (78%)
CrystalDiskMark QD32 Sequential Read (MB/s)	3,400	3,507 (3%)
CrystalDiskMark QD32 Sequential Write (MB/s)	1,720	2,739 (59%)
3DMark: Fire Strike (Index)	11,101	37,148 (235%)
Rise of the Tomb Raider (fps)	46	118 (157%)
Total War: Warhammer II (fps)	39	87 (123%)
Tom Clancy's Ghost Recon: Wildlands (fps)	60	144 (140%)

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

Our desktop zero-point consists of an AMD Ryzen 5 1600, 16GB of Crucial Ballistix Sport LT @ 2,666, an EVGA GeForce GTX 1060 3GB, and a 250GB Samsung 960 Evo M.2 PCIe SSD. All tests were performed at 1080p at the highest graphical profile.

VERDICT **7**

Origin PC Millennium

BOSS Innovative; robust customization options; easily accessible components; incredible performance.

BUST Huge, heavy case; expensive; runs hot.

$5,547, www.originpc.com

SPECIFICATIONS

Processor	Intel Core i9-9900K
Graphics	Dual GeForce RTX 2080 Ti (SLI)
RAM	Corsair Vengeance RGB Pro 32GB 2,666MHz (4x 8GB)
Motherboard	MSI Z390 Gaming Edge AC
Primary Storage	500GB Samsung 970 Evo Plus
Additional Storage	3TB HDD
Cooling Solution	Corsair H100i 240mm white closed-loop cooler
PSU	Corsair RM1000i with white sleeved cables
Case	Origin Millennium
Warranty	Lifetime 24/7 US-based technical support, free lifetime labor, one-year warranty, and 45-day free shipping

A beast in terms of both proportions and performance.

HP Spectre X360

Not the best ultraportable, but one of the prettiest

WELL, IT CERTAINLY looks nice. HP's new notebook is a sleek little number, with its touchscreen, digital stylus, and 360-degree hinges for swapping between different configurations. Our review model comes with a lovely matt finish with rose-gold accents. It's certainly easy on the eye, and easy to use; touchscreen control is smooth and effective, and the 13-inch screen provides excellent sharpness and color contrast. The maximum brightness does leave a little to be desired, though, struggling a bit in brightly lit environments.

Performance-wise, this isn't going to blow any minds, but it does its job well. The Spectre X360 13-ap0038nr—catchy, we know—packs an Intel Core i7-8565U processor with integrated UHD 620 graphics. That's a quad-core CPU with a base clock of 1.8GHz, and Intel claims that its Turbo Boost technology can lift the frequency up to a maximum of 4.6GHz. HP offers a variety of performance modes and thermal settings for tweaking how you want your laptop to run; we found that this machine did get quite warm and noisy under CPU stress. With 16GB of DDR4-2400 memory, the Spectre X360 is best suited for image manipulation and office work, rather than heavy-duty gaming and 3D rendering.

The 512GB M.2 SSD boasts brilliant read times, on par with the best M.2 drives available right now, although write times came back tragically slower—barely superior to conventional SATA drive speeds. For connecting other hardware, there's a single USB 3.1 port on the left-hand side, and two Type-C ports on the other, joined by a standard headphone jack and a microSD card reader. The Spectre charges from these ports, too; one is offset diagonally on the top corner of the chassis, intended for charger connection.

It's not as small and lightweight as some notebooks currently on the market, thanks in part to a thick bezel on the lower and upper edges of the screen, the latter of which houses HP's own Wide Vision FHD IR camera and a dual-array microphone setup. Audio is a pretty big deal with this notebook; HP has teamed up with Bang & Olufsen to deliver high-quality sound via four speakers and HP's Audio Boost 2.0. Paired with the sharp WLED-backlit screen, watching videos on the Spectre X360 certainly makes for an enjoyable experience.

Also in the box is an HP Tilt Pen, a powered stylus with two buttons. This is by far the best way to use "tablet mode"; once calibrated, the stylus is precise and effective, and the buttons can be remapped to perform various functions, such as bringing up the Windows Ink sketchpad. Touchscreen control with a fingertip is also an option—and better for quick taps in laptop mode, because pressure from the pen has a tendency to make the screen shift on its hinge a bit—but extended use is sure to leave your screen covered with fingerprints.

One of the more original features on display here is the integrated privacy screen function, HP Sure View. With the tap of a button (F1, to be exact), a screen polarization effect is instantly triggered that renders the screen completely obscured to anyone looking at it from outside a narrow cone of visibility. Security features have all been quite well thought out by HP for this laptop; the camera comes with a physical independent power switch on the side of the casing, and can be used for facial recognition login on Windows 10, and—like many modern laptops—it comes equipped with a fingerprint scanner beside the trackpad.

Finally, an oft-contested point of machine quality for notebooks: battery life. The Spectre is impressive in this department, capable of providing 14 hours of charge for working on the move. The lithium-ion battery weighs 250g and is supplied by a 65W AC adapter, which supports fast charging, thanks to USB-C—the battery is capable of charging to 100 percent in approximately one hour. With that in mind, we feel comfortable saying that the Spectre X360 is a solid piece of gear. **–CHRISTIAN GUYTON**

VERDICT **8**

HP Spectre X360 13-ap0038nr

FRIENDLY GHOST Elegant design; fast SSD reads; thoughtful security features.

JUMP SCARE Fan is noisy; a bit heavy for a notebook; unimpressive SSD write speeds.

$1,479, http://store.hp.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	743	561 (-24%)
CrystalDisk QD32 Sequential Read (MB/s)	563	3,100 (451%)
CrystalDisk QD32 Sequential Write (MB/s)	133	557 (319%)
3DMark: Fire Strike (Index)	13,202	1,062 (-92%)
Rise of the Tomb Raider (fps)	99	5 (-95%)
PCMark (Index)	2,379	2,543 (7%)
Battery Life: Movie Playback (Mins)	183	840 (359%)

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

Our laptop zero-point is the Asus GL502VS-DS71, with an Intel Core i7-7700 HQ, an 8GB GTX 1070, and 16GB of DDR4-2400. All game tests are performed at 1080p at the highest graphical profile.

SPECIFICATIONS

Processor	Intel Core i7-8565U
Graphics	Integrated Intel UHD Graphics 620
RAM	8GB DDR4-2400 SDRAM
Screen	13-inch 1080p 72 percent NTSC color gamut
Storage	512GB PCIe NVMe M.2 SSD
Keyboard	Full-size island-style backlit
Battery	Four-cell 61Whr
PSU	65W USB-C
Weight	2.9lb
OS	Windows 10 Home 64-bit

The screen is made of extra-durable Gorilla Glass.

This motherboard has more pins than a voodoo doll factory.

MSI MPG Z390 Gaming Edge AC

Price-smart performance

THE MPG Z390 Gaming Edge AC falls at the less expensive end of the motherboards we tend to review, but it's no less impressive for it. Initial examination had us hopeful—despite it only being a standard ATX size, MSI has worked hard to cram a lot of features on to this board. Designed to support eight and ninth-generation Intel Core CPUs, the Edge AC comes with a veritable slew of ports and pins, meaning it's more than capable of carrying a high-end build, despite costing less than two hundred dollars.

MSI is a trusted household name when it comes to PC building, so its products come with a certain expectation of quality. Thankfully, this Z390 doesn't disappoint; it might not crack the overall performance of some motherboards, but it can keep up with boards almost twice its price. Even while running Prime95 to heavily stress the processor, this board only drew a maximum of 148W of power. Other benchmarks came back identical to tests with more expensive boards, which was satisfying to see.

Statistics only tell half the story, though, so we turn to the physical board itself. The true judge of a mobo is the variety of its features, and this Z390 is fully loaded. The rear I/O comes equipped not just with standard USB 3.1 ports, but also a USB Type-C connector, along with both HDMI and DisplayPort cables for those looking to use integrated graphics. Beyond that, there's the usual selection of audio ports, and support for a few older formats, such as the faithful PS/2 port.

CLOCK-WATCHING

On the main body of the board, there's another wealth of connectors. The standard eight-pin CPU power connector is joined by a supplementary four-pin connector, for supplying extra power to the processor to improve overclocking potential. This isn't a board for hardcore overclockers, but if you're inclined to squeeze a bit more power from your rig, it should have you covered. The (fairly ugly) BIOS comes with a function called Game Boost, which automatically shunts your CPU up a few megahertz, but doesn't push its limits. Proper overclocking is possible, but we struggled to get a stable overclock of more than 5.0GHz out of our Core i7-8700K processor.

For more esoteric builds, there are three types of lighting connectors: two standard four-pin RGB LED ones, joined by a three-pin rainbow LED connector, and a three-pin specialized connector for Corsair LEDs. The Z390 comes with its own RGB lighting, although it's a fairly simple affair. Being an MSI product, though, it does come with the company's Mystic Light software, which allows for some flashy arrangements with compatible hardware. Elsewhere, we've got support for five system fans, a water pump for liquid-cooled builds, even a TPM module. If you're craving speedy data transfers, the Z390 can be fitted with a Thunderbolt add-on card, too. While this board does come with some heat spreaders, there's no integrated heatsinks for the two M.2 drive slots, which feels like a missed opportunity.

Audio is a pretty big deal with this mobo. It features Audio Boost 4, which includes a high-definition audio processor, amplifiers, and capacitors, all of which is isolated from the main board circuitry to improve audio signal. This is powered by Nahimic audio software. MSI's marketing material purports that Audio Boost 4 functions like a dedicated soundcard, and while this doesn't quite ring true in practice, it's a good feature.

When we look at this board, it doesn't make our hearts sing with excitement, but it is still very good. It can prop up far more expensive components with ease, and its sensible price point means that it represents a solid starter motherboard for those building an Intel system for the first time. Wi-Fi compatibility is a nice bonus, too, although any serious user is likely to have this plugged in via Ethernet. When it comes down to it, we have no qualms giving the MPG Z390 a hearty recommendation. **–CHRISTIAN GUYTON**

VERDICT **9**

MSI MPG Z390 Gaming Edge AC

LOOKING SHARP Fully equipped rear I/O; low power draw; good integrated audio; plenty of connectors.

CLIFF EDGE No heatsinks for M.2 drives; BIOS is hard to navigate; weak at overclocking.

$190, http://us.msi.com

BENCHMARKS

	MSI MPG Z390 Gaming Edge AC	Asus Maximus XI Gene
Tech ARP's X264 (fps)	**31.08**	29.68
Cinebench R15 Multi (Index)	1,370	**1,389**
Fry Render (m:s)	**02:23**	**02:23**
AIDA64 Memory Latency (ns)	52	**47**
CrystalDisk QD32 Sequential Read (MB/s)	548	**550**
CrystalDisk QD32 Sequential Write (MB/s)	**525**	495
Power Draw Idle/Load (Watts)	**40/148**	42/307
Total War: Warhammer II (Avg fps)	**56**	**56**
Lowest Voltage @ 5.0GHz (Volts)	1.36	**1.22**
Maximum OC Achieved (GHz @ V)	5.0 @ 1.36	**5.1 @ 1.32**

Best scores are in bold. Our test bed consists of an Intel Core i7-8700K, 16GB of Corsair Dominator Platinum DDR4 @ 3,200MT/s, an Nvidia GeForce GTX 1080, and a 250GB Samsung 850 Evo. *Total War: Warhammer II* was performed at the ultra preset at 1440p.

SPECIFICATIONS

Chipset/Socket	Z390/LGA1151
Form Factor	ATX
Memory Support	64GB (4x 16GB) @ 4,400MHz
M.2/U.2 Support	2x M.2
SATA Support	6x SATA 6GB/s
Max PCIe Support	3x 16 (x8x8x4)
Rear I/O	3x USB 3.1 Type-A, 1x USB 3.1 Type-C, 2x USB 2.0 Type-A, 1x HDMI, 1x Intel Gigabit Ethernet, Wireless A/C, PS/2 combi port, 5.1 audio out, optical audio out

Optoma UHD50

Affordable 4K projection, DLP-style

LET'S GET ONE THING straight, with 4K clarity: The UHD50, one of Optoma's latest range of 4K-capable projectors, isn't a native UHD model. It's a 4K pixel shifter. That means it uses a 1080p DLP chip, and "shifts" the image at high speed to create a full UHD pixel grid.

But there's pixel shifting, then there's pixel shifting. Optoma claims its take on it is superior. Or rather, it's the pixel-shifting tech from Texas Instruments, known as XPR, that's superior to its main competitor, that of LCD projectors.

The idea is fairly straightforward to grasp: Project an image, then shift it slightly, and project it again with updated pixel data, but do it so fast the human eye perceives the result as a single, unified image. In really simple terms, you can think of LCD pixel-shift projectors as bumping the image once diagonally.

Pixel-shifting 4K LCD projectors thus offer double the truly addressable pixels of a 1080p model. Of course, full 4K is four times the pixels of 1080p, so you're only getting half the detail. With TI's XPR pixel shifting, the 1080p image is moved right, then down, then left, delivering fully four times the pixels of 1080p. This all happens fast enough to be imperceptible. In practice, the projector runs at 240Hz, and thus delivers 4K at an effective refresh rate of 60Hz. It'll also run as a native 1080p projector at up to 120Hz.

The big question is whether this approach delivers what it promises, namely a true 4K experience. Subjectively, the answer is no. We're pretty familiar with the LCD approach to 4K pixel-shift technology, and this DLP take is only a marginal improvement. It remains obvious enough when observing, for instance, smaller-point fonts in Windows that you're not experiencing full 4K.

That impression is a lot less obvious with high-quality 4K video content, which looks far sharper and more detailed than the 1080p alternative. But so does a pixel-shift LCD projector. The fact remains, though, if you want a true 4K experience, there's no substitute for a native 4K projector. The only problem is that native 4K requires relative megabucks, while you can snag this beamer for $1,200.

Of course, the UHD50 is not the only pixel-shifting projector, so the question of whether you should buy it comes down to its broader capabilities and performance, which are mixed. We're not blown away by the quality of the UHD50's optics. For starters, the lens shift is limited to the vertical axis. That's compounded by slight imperfections in image geometry, in our sample unit at least, which make attaining a perfect setup elusive.

This projector also suffers from a "light border" around the projected image. It's substantial in size rather than intensity, and only a minor distraction, but unwelcome all the same. Elsewhere, in SDR mode, contrast is good rather than spectacular. Still, for this reviewer, who is sensitive to the rainbow effect associated with DLP projectors, the good news is that there's little of that in evidence. Another upside involves gaming. Along with 4K at 60Hz and 1080p at 120Hz, it looks great in game at an interpolated 1440p.

Less impressive is the UHD50's HDR implementation. Like a lot of so-called HDR PC monitors, better to think of this as a projector that can process an HDR signal rather than one that can do full justice to HDR content. The UHD50 doesn't dramatically move the game on—it's a decent all-around projector, and we'd take it over a 1080p model, but it doesn't achieve the holy grail of a full 4K experience on the cheap. **–JEREMY LAIRD**

VERDICT **7**

Optoma UHD50

OSCAR WINNER A big step up in detail versus 1080p; good for gaming.

GOLDEN RASPBERRY Still not true 4K; some image quality issues.

$1,199, www.optoma.com

SPECIFICATIONS

Projection Technology	DLP
Resolution	3840x2160 (1920x1080 DLP chip with pixel shift)
Brightness	2,400 lumens
Contrast	Up to 500,000:1
Color Wheel	RGBRGB six-segment
Throw Ratio	1.21–1.59
Optical Zoom	1.3x
Refresh	4K @ 60Hz, 1080p @ 120Hz
Inputs	HDMI 2.0 x1, HDMI 1.4a x 1, VGA

Optoma's new UHD50 uses Texas Instruments' XPR pixel-shifting tech.

Logitech G502 Lightspeed

The best mouse made better?

LOGITECH'S LIGHTSPEED tech has wowed us in keyboards, but squeezed into a compact mouse, it's easy to argue that the super-low-latency wireless protocol is where it needs to be. A good keyboard tends to stay where it is. Going wireless for keys is merely a matter of occasional convenience; rarely do you type so hard and so excitedly that a wire becomes a problem—if you do, perhaps it's time to take a look in the mirror and ask some difficult questions. A mouse is made to move, and boy, does this Lightspeed edition of the iconic G502 move.

The updated HERO sensor (now capable of an unnecessarily fine 16,000 dpi) is unerringly precise, the light-bodied mouse is slick underneath for maximum ease of travel, and it's intricately and stiffly molded to the point that we didn't notice the apparently thinner plastic employed in this new model in order to cram in the wireless tech. As long as you're a right-hander, the narrow body feels great in the hand, with an integrated thumb rest and textured silicon (which, on the left, curls around to reach all the way up to the palm), adding reassurance when things get slippery. If you like a heavier mouse, or want precise control over balance, there's a number of weights in the box, which can be slotted into your choice of position underneath.

The G502 Lightspeed is not short on buttons. It's positively dripping with them, in fact: There's a pair of thumb buttons, with a third "sniper" button mounted at the very tip of the thumb; a pair of DPI buttons set to the left edge of the left mouse button; the requisite top buttons, with the left feeling lighter to click than the right; a top button that seeks a connection between the mouse and its USB receiver; and three ways of actuating the wheel, with a central click and left and right nudges counting as individual functions.

What's more remarkable is that we didn't have any of our usual reservations about the layout. At least to these large hands, everything is where it needs to be. Take that sniper button, for example. Some mice put it right on the pad of your thumb, but the G502 has it just slightly out of reach, requiring the tiniest palm readjustment to actuate it. That's perfect, because it's an occasional function, not a core one. Likewise the DPI buttons, which ask you to shift your pointer finger to the side slightly to switch. Not something you'd accidentally do, but not something that's difficult to reach—and a damn sight more convenient than searching for top-mounted DPI switching in the heat of battle.

As well designed as it is, though, this isn't a perfect mouse. The G502's spoked wheel (or at least half of it) is its one misstep. It's a dual-mode number, with a nice clicky mechanical switch toggling between ratcheted and free-wheeling modes, but only the latter gets it right. Quality bearings mean that there's a supreme amount of spin—we counted some 13 seconds in a completely non-scientific test—and it's incredibly smooth. The ratcheted mode, however, is rough and unpleasant, particularly when compared with other dual-mode mouse wheels we've tried. Clicking the wheel's side switches is easy enough, but clicking down as a middle button requires a Herculean feat of strength which, on one hand, is a boon if you're prone to heavy-fingered misclicking, but on the other, it's annoyingly difficult if you're letting the wheel run free. Honestly, we would have probably dropped the toggle altogether in favor of a better-feeling ratchet.

Yes, it's expensive. Very. But you're paying for a wireless mouse that, thanks to that Lightspeed protocol, is indiscernible in the quality of its operation from a wired one. A mouse form that's already well established and well respected, made even better than before. A considered and incredibly careful piece of engineering. It's worth every cent. –ALEX COX

VERDICT **9**

Logitech G502 Lightspeed

FREEDOM Superb design; great comfort; excellent sensor; stacks of customization.

IMPRISONMENT Slightly wonky wheel; high price.

$150, www.logitech.com

SPECIFICATIONS

Sensor	Optical
Sensitivity	16,000 dpi
Sensor Model	Logitech HERO 16K
Polling Rate	1,000Hz
Programmable Buttons	10
LEDs	RGB
Battery	Up to 60 hours, Powerplay wireless charging compatible

Thermaltake Level 20 RGB Titanium

Fully loaded, and full of flair

OUR FAVORITE FEATURE of the Level 20 RGB is the kitchen sink Thermaltake has thoughtfully included on the underside. Oh ho! No. Just our little joke. There's no kitchen sink. But that's about the only modern convenience the company has deemed unworthy of this heavy, huge collection of features masquerading as a keyboard. Really: It is crazy stacked, like the foot-wide Swiss Army knife they keep in that one case at the front of the outdoors store. But this is not just a gimmick. It's a keyboard. And it's good.

Let's get its big annoyance out of the way. There's a notched cutout, as is the fashion, but Thermaltake has placed it on the front, in line with the top-mounted RGB strip, which separates the main body of the keyboard from the navigation cluster and 10-keys. Sure, this looks great, but it has incredibly sharp corners; depending on the size of your hands and the angle at which you hold your wrists to type, you may find that it irritates your delicate right palm. Reminds you that you're alive, we suppose. There's also no wrist rest, possibly because of the awkwardness of that notch.

Apart from that, it's a cavalcade of features worthy of Thermaltake's traditionally exorbitant Level 20 line. Dedicated media cluster with volume roller? Check. Full RGB? Check. And let's add a light ring around the base of the keyboard (and the aforementioned top-mounted light bar) for good measure. Game mode and Windows key lock? Psh, of course. On-board profiles? Six, and you can customize them either on the keyboard itself, through the driver, or with TT's somewhat wonky smartphone app. There's N-key rollover with antighosting, because of course there is. Would it be churlish for us to moan that there are no analog keys, given that's the new tech on the block? It would, because analog keys are silly and niche.

The real question is how well this big brown paper bag of features has been packed. We're happy to say that the bottom of the bag remains intact, and the bread hasn't been crushed: The combo has been pulled off perfectly. That lighting, through clear-based Cherry MX Speed Silver switches on a matt black base, looks glorious, beaming out lurid brights and pastel shades with equal aplomb. The switches, Cherry's high-actuating version of its moderately resistant silent Red switches, feel beautiful and act fast, and they're mounted on a heavy and sturdy case, which offers more than enough stiffness while typing, along with reassurance while thrashing around in games. They also sound pleasant when bottoming out—this could well be the best experience we've had with Silver switches yet.

Around the back, we're impressed (though unsurprised) that Thermaltake has also crammed in both USB 2.0 pass-through and the same for a four-pole jack, meaning you can easily extend a headset—though, if we must pick on something, the wired-in braided cable is thick and unwieldy, and given that we're starting to see USB 3 keyboards that can carry pass-through with a thinner, replaceable cable, we'd say that's a notable omission. The volume roller could probably be smoother (it feels a little cheap), and the on-board effect controls, while numerous, aren't exactly intuitive. Plus points, though, for the ability to hook it up to both TT's RGB Plus system and, through that, Razer's Chroma lighting, for those who like their rainbows to be all in sync.

All in all, this is a very decent and accomplished keyboard that inevitably has the features you want. We're happy to recommend it. If we didn't feel like we needed every one of these features, we'd likely choose something cheaper (and there's plenty cheaper), or more special (such as Razer's optical Huntsman, which we're still a little obsessed with), but there's something about having everything that's attractive. –ALEX COX

VERDICT **8**

Thermaltake Level 20 RGB Titanium

TITANIUM Absolutely dripping with features; pleasing key feel and sound; great lighting.

WHYTANIUM Uncomfortable cutout; thick cable; slightly confusing.

$150, www.thermaltake.com

SPECIFICATIONS

Switch Type	Cherry MX Speed Silver
Form Factor	Full size
Media Keys	Yes
Macro Keys	Customizable in software
LEDs	Per-key RGB
N-Key Rollover	Yes
Pass-Through	USB 2.0, 4-pole 3.5mm jack
Dimensions	18.9 x 7.3 x 1.7 inches
Warranty	12 months

Sennheiser GSP 670

A truly luxurious wireless offering that really sings

WE'VE GOT NOTHING AGAINST quality wired headphones, but the freedom promised by wireless cans has us constantly on the lookout for that particular audio nirvana. The Sennheiser GSP 670 shares many mechanical similarities with the existing GSP 600 wired model, with the same speaker technology in each earcup, but this cable-free version features a 20-hour battery life and very low latency. Bluetooth compatibility means the GSP 670 can be used with just about any device you can throw at it, too, from consoles to smartphones, and tablets.

The GSP 670 continues the family aesthetic, which could be described as "Terminator's earmuffs." The look is probably the aspect we're least enamored with overall, but in fairness, Sennheiser is right to keep the color scheme muted by using black and gray, and to avoid RGB lighting or accent colors. With this many angles and surfaces, you don't need any additional details.

Fortunately, the GSP 670 looks this way as a result of some careful technical design in the name of comfort. At 14oz, it's on the heavy side, but this isn't an issue, thanks to the mechanical outline of the headband and metal single-sided yoke, and an adjustable calliper pressure system at the top of the headband that brings a real USP to the GSP series. By adjusting two sliders at each side, you can precisely control how much pressure the earcups exert on your cranium.

A perennial favorite feature of ours about Sennheiser gaming headsets is the boom arm design, with a mic mute built in so that you're automatically muted when pushing the arm up, and broadcasting when it's down. The satisfying click you feel when doing this really tells of the construction quality—we defy you not to move it up and down aimlessly, just enjoying the sensation, when you first use the headset.

Not much has changed in the audio department compared to the wired GSP 600. The same neodymium magnet drivers articulate the sound, and the response is noticeably powerful at the bass end, more so than previous Senny models, such as the Game One. There's always a slight trade-off when the EQ curve is styled to sound good, rather than to sound totally flat, as with studio monitors, and usually it comes in the tiny details in the upper mid-range and in the treble. The question is whether the overall sound is better for its intended purpose when it's been sculpted in this way. The answer is, categorically, yes.

You couldn't master an album using them, but for gaming, movies, TV, and music, these cans sound wonderful. There's a liveliness to them—which we suspect comes down to the luxuriousness of the contact points as much as the drivers themselves—which means you can feel the music swelling and pulsing in pressure changes, as well as hear it. It's a sensation we've always loved in Bose's closed-back headphones, and we're thrilled to find it in the gaming market. Some gamers might find it too busy at the bass end, but the GSP 670 really speaks to our personal preference. This is a surround-sound compatible headset, too, so if you want to get serious and listen out for positional audio cues in the likes of *CS:GO,* Sennheiser's proprietary surround algorithm has your back.

This is the most complete and best-sounding gaming headset package Sennheiser has put together to date. It's also very expensive. That makes us hesitant to recommend it as the next "no-brainer" pick in the market, but for those willing to pay a little extra for increased durability, replaceable parts, and a real feeling of luxury, they'll be richly rewarded for their outlay. The sound is fantastic, but the same was true of the cheaper GSP 600—and indeed much cheaper rivals from SteelSeries and HyperX. –PHIL IWANIUK

VERDICT **9**

Sennheiser GSP 670

FREEDOM Useful control layout; boom arm mic mute system; powerful bass; optional surround.

RESTRAINT Very expensive; looks busy; rivals offer similarly great sound.

$349, http://en-us.sennheiser.com

SPECIFICATIONS

Driver Type	Neodymium magnet
Impedance	28 Ohms
Frequency Response	10Hz–23KHz
Design Style	Closed back
Microphone Type	Bidirectional electret condenser
Connectivity	Wireless via USB, Bluetooth 5
Weight	14oz
Battery life	16 hours via USB dongle; 20 hours via Bluetooth

Cooler Master MasterBox Q500L

An adaptive case on a sensible budget

THE MASTERBOX SERIES has produced some decent budget cases in the past, and the Q500L is no exception. At just $60, it looks pretty unremarkable at first glance, but behind its polka-dotted steel frame and patterned magnetic dust filters, a broad selection of clever customization options is concealed.

First off, there's no PSU shroud; the power supply sits in an internal bracket that attaches to the interior of the case, at the front for an ATX board, or in the rear-bottom position if you're using a smaller ITX board. It then connects to a fitted cable, which feeds back through to a standard three-pin socket at the rear. This makes for a neat power solution, but the bracket has to be removed in order to fit the PSU, and there's no way to access the power button once the case is closed.

Three of the short sides are identical, using a simple perforated metal design that enables fans, screws, or brackets to be fitted in essentially any orientation, then concealed behind the dust filters. In its default setup, the base is fitted with rubber-soled feet, but these can be removed and replaced on the front or top if you wish to mount it differently. The case can also be laid on its side, using rubber washers as feet for the screws holding the steel side panel in place.

The adaptability doesn't end there. The windowed side (a cheap piece of plastic) also holds the front I/O, which can be easily unscrewed and attached to a different side. The window panel is square, so it can be rotated 90 degrees to fit the new I/O position. It's a minor addition, but will no doubt appeal to a niche of users; the front I/O is fairly basic, with two USB ports and jack inputs for headphones and mics. This adaptive mentality extends to the drive mounts—two brackets sit behind the metal mobo plate, each capable of fitting one 3.5-inch HDD or two 2.5-inch SATA SSDs.

In spite of the acrylic window panel, the case as a whole feels well constructed and relatively sturdy. It's not heavy, though, weighing under five pounds. It's not big either; long PSUs will cause difficulty with the front I/O cables (which makes repositioning the I/O a good option), and if you want to liquid cool your build, you're limited to an absolute maximum of 360mm of radiator space. This isn't a case for serious overclockers.

In cooling terms, the case comes with one standard 120mm Cooler Master fan at the rear, with capacity for up to four more on the top and bottom sides. The pre-installed fan is faintly irritating when fitting the motherboard, as it leaves very little clearance over the rear I/O slot. Fitting the motherboard is generally a chore; the PSU bracket can get in the way, and the front I/O cables need to be bundled aside to squeeze the board in.

The Q500L suffers from an identity crisis. It's priced as a budget product, making it a good choice for a novice builder, but its wealth of nifty features is unlikely to be of use to a beginner. Despite that, it isn't a bad case for a rookie to start off with, although it's a little lacking in the cable management department. The space behind the motherboard plate has good routing room for cables, but the main cavity could use a few more slots for securing cable ties.

There are a few other issues: GPU clearance is a little limited, meaning that this case is ill-suited to cards with three fans, and it only comes with two of the stylized magnetic dust covers (three would be ideal for horizontal orientation). Even so, we feel pretty comfortable recommending the MasterBox Q500L. It has enough funky features to appeal to an experienced tinkerer on the hunt for a budget build, and it's sensibly priced and accessible, making it a good choice of case for a first build. –CHRISTIAN GUYTON

VERDICT **8**

Cooler Master MasterBox Q500L

MASTER Brilliant potential for customization; good use of internal space; great value for money.

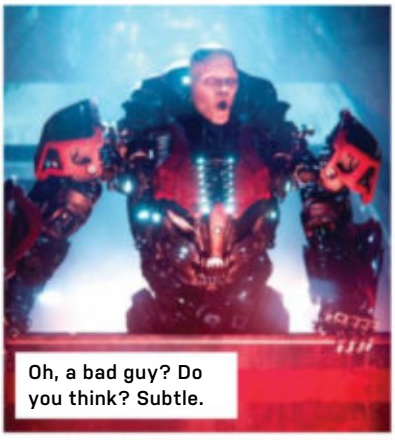
DISASTER Flimsy plastic window panel; cable management is difficult.

$60, www.coolermaster.com

SPECIFICATIONS

Form Factor	Mid-tower
Motherboard Support	ATX, mATX, ITX
Colors Available	Black
Window Available	Yes
3.5-Inch Support	2
2.5-Inch Support	4
Radiator Support	240mm roof, 120mm rear
Fan Support	2x 140mm roof, 1x 120mm rear, 2x 120mm base
Dimensions	15.20 x 9.06 x 15.00 inches
Graphics Card Clearance	14.17 inches
CPU Tower Clearance	6.29 inches
Weight	4.83lb


Rage 2's signature color is hot pink, seen here in the arrows that guide you.


Oh, a bad guy? Do you think? Subtle.


Towns are intelligently laid out, full of conversations and side missions.


There's a weirdly large number of CRT monitors in the future.

Rage 2

Devs team up for post-apocalyptic sequel

THE COMBINATION of *Doom* and *Quake* originator id Software and *Just Cause/Mad Max* dev Avalanche Studios should be potent, both firms having behind them the smoking wreckage of multiple first and third-person shooter hits.

Running on Avalanche's Apex engine, the game exclusively uses the Vulkan API, and seems tied to frame rate in a strange way. The graphics options want you to pick a rate it can stick to, going so far as to render at a lower resolution on the fly before upscaling to your preferred output resolution. Turn all this off, allow the frame rate to drop, and the game seems slower as a result.

This means it's extremely smooth—the slippery feeling of previous id games combining with biomechanical enemies to evoke the sense of a *Quake 4* sequel as much as the follow-up to John Carmack's 2011 swansong.

The world of the first *Rage*—devastated after the collision of asteroid 99942 Apophis with Earth in 2029—returns, along with gibbering mutants, trigger-happy bandits, cybernetically enhanced Authority figures, and the Arks full of buried goodies, including nanotech superpowers. Apart from this, there's no major plot link to the previous game.

You're thrown out into the wasteland with nothing but a suit of high-tech armor, a vehicle, some guns, the series's trademark "wingstick" boomerang, and a list of three people to find. Discover the first, after a short but exhilarating drive through the dust roads and rocks left behind after the apocalypse, and one of the best sewer-crawling mutant hunts we've played, and side missions open up.

Play it in linear order and you might think *Rage 2* is short, but it's designed to be explored rather than blasted through in one go. And that's where the problems start, because an open-world shooter with vehicles and fast travel is exactly the sort of game that tempts you to follow its critical path to the end. It doesn't help that the wasteland is dull, and the sight of shots being fired just over the next hill aren't always enough to draw you in.

That's a shame, because the game has some of the best combat currently available. An Overdrive mode, which powers up your shots and regenerates your health, is activated after collecting enough Feltrite—blue glowing capsules dropped by dead enemies. They can be attracted to you, but the main way to get them is to run over them, making run-and-gun close-up tactics the best way to progress, going berserk with your abilities until no one is left standing.

Rage 2 shows what a partnership between id and other devs can bring. It's a bland world, but there's enough sparkling gunplay and super-powered massacres to make it worth exploring. **–IAN EVENDEN**

VERDICT 7

Rage 2

RAGING Excellent shooting with enemies who are good to shoot; excellent vehicles, too.

AGING Occasional texture pop; bland world; strange softness about everything.

RECOMMENDED SPECS i7-4770/Ryzen 5 1600X; 8GB RAM; GTX 1070/Vega 56.

$60, www.bethesda.net, ESRB: M

The rats act almost like a fluid, scuttling and washing over each other.

After a tutorial with your mom, you're on your own in the world.

Skin textures are beautifully handled.

A Plague Tale: Innocence

Childhood haven becomes stealth-game terror

HAVING CHILDREN in games is often a bad idea, as things have the distinct chance of going all Ned Umber at the end of *Game of Thrones* S8 E1. And no one wants that. Brave of French dev Asobo, then, to not only put children front and center in *Innocence,* an adventure with lots of stealth set in medieval France, but to pit them against hordes of flesh-eating rats.

Siblings Amicia and Hugo live in some spectacular French countryside, hunting boar and worrying about the rain that's ruining the harvest. Hugo has a mysterious illness for which his mother is researching a cure, and it's this, as well as the boy, that brings soldiers to their home. After sneaking out with their mother, the pair is left alone with vague directions to seek a doctor and follow the river.

The first thing you notice about *Innocence* is how good it looks. The forest is a step above what we've seen before in *Edith Finch* or *Kingdom Come.* The visual fidelity means that when the rats appear, they're as fearsome as the trees are beautiful. A scurrying, writhing mass of red eyes and long tails, they're not the friendly pet kind. Using a lit torch pushes them back, but what this reveals might be worse—the half-consumed bodies of whatever had got in the rats' way last.

Innocence casts you as Amicia, leading Hugo, occasionally leaving him alone or sending him on errands through gaps only he can fit into. Leave him for too long, and his cries attract soldiers. You're helpless in the face of armored men, the slingshot you carry initially only useful for distraction. Eventually, you learn to craft potions with which to direct the tide of rats, or force soldiers to remove their helmets with a chemical burn. Once bareheaded, a stone can be used to crack their skulls, at the cost of making noise.

Controlling a pair of characters who hold hands and frequently hug together out of fear is a new experience, and the relationship between the siblings is real and touching. However, the game suffers from a slow beginning, the one-hit kills starting to grate until you perfect your route through a level, and with environmental puzzles that are more stressful to complete when you need to be hidden. Even worse are the "boss" encounters that end certain sections, which see you circling around and around, trying to pick off weak points with your sling. To have something that reminds you so strongly that you're playing a videogame plopped in the midst of some atmospheric and involving action snaps you out of your suspension of disbelief almost immediately.

While the rats, and the impressive tech that powers them, are the main draw, what keeps you playing is the need to keep sympathetic characters alive against the monsters in the darkness. **–IAN EVENDEN**

VERDICT 8

A Plague Tale: Innocence

RATTY Realistic familial relationship; amazing looks; moments of utter terror.

TATTY High specs for 4K; rats will make your skin crawl; occasional poor design.

RECOMMENDED SPECS i5-4690/FX-8300; 16GB RAM; GTX 970/RX 48.

$45, www.aplaguetale.com, ESRB: M

LAB NOTES

ALAN DEXTER, EXECUTIVE EDITOR

Respect the Past, Don't Ray-Trace It

Yesterday's favorites shouldn't be showcases for future tech

QUAKE II IS THE LATEST in a long line of games to get some retro love, with Nvidia releasing the RTX rendition of the id Software classic. This remastered version adds ray tracing to the first-person shooter, and transforms its limited gray, beige, and brown palette to a slightly lighter gray, beige, and brown. There are a few mirrored surfaces to stare briefly at, and a smattering of upgraded models, but largely it's the same game from 22 years ago, with nominally prettier visuals.

And it's a complete waste of everyone's time.

Not only does it not look particularly inspiring, and therefore completely fails at its primary goal of selling real-time ray tracing, but it doesn't play particularly well either. Gameplay has come on in leaps and bounds in the last two decades, and this just feels like an old game that has been bettered multiple times over. If you want a first-person shooter, then this is not the game you're looking for. It also runs terribly: 22fps at 4K on a 2080 Ti in RTX mode, as opposed to 997fps using the OpenGL driver.

Don't get me wrong, I loved *Quake II* when it was originally released. I have a lot of fond memories of playing it back in the day. And, indeed, playing through the first few levels again, I even managed to recall where the hidden areas were. But I've no real interest in playing it through again. None. Been there, done that.

This attitude sums up my feelings for *World of Warcraft Classic,* too. I played it at the time, and don't need to play it again. If you were too young or too old to enjoy it back then, it's a great experience,

Destroy your frame rates in a classic twitch shooter today.

but simply going back and doing it again now holds no interest. I'm much more interested in moving games forward than revisiting how good they used to be and seeing if we can take them in a different direction by constantly revisiting them and asking the same questions.

CHRISTIAN GUYTON

Staff Writer

I'm a tad nervous about the packaging for the third-gen Ryzen CPUs. It seems that AMD and Intel are gripped by an inexplicable need to make their CPU packaging as over-the-top and pointless as possible. I think it's wasteful; the Threadripper cases, in particular, are faintly absurd constructions of hard plastic and polystyrene in lurid orange. Why does the Core i9-9900K come in a bizarre dodecahedral box? That's not for lesser minds to know. I feel as though I'm trying to solve a puzzle on a late-night game show, encouraged by an unseen cheering audience. What will the Ryzen 3000 series bring? I'm hoping for a box that's bigger on the inside.

BO MOORE

Hardware Lead

Oh no, I'm playing an MMO again. As I write this, I'm reinstalling *Final Fantasy XIV.* I played it a bit back in 2013, but not more than a few months. My real MMO heyday was *World of Warcraft,* on which I spent several of my high school and college years. But *XIV* has somehow managed to pull me back in. The game has a new expansion launching soon (it'll be out by the time this goes to print), and a ton of my friends are playing right now. Alas, such is the draw of the MMO community. Would I play it by myself? Almost certainly not. But with old friends and new logging in on a nightly basis, I'm looking forward to diving back into the MMO world for a bit.

Editors' Picks:
Digital Discoveries

Hardware staff writer, Joanna Nelius, and senior editor, Jarred Walton, reveal the gear that improves their lives

LEXIP PU94 GAMING MOUSE

I saw some neat peripherals at E3, but one stood out to me in particular: the Lexip Pu94 gaming mouse. It's specifically designed to work with flight sims and city-building games with its two built-in joysticks. One is a small thumbstick on the left side, where some gaming mice have buttons; the second is built into the top half of the mouse, and is controlled by rocking your hand slightly in all directions. Both joysticks make this mouse incompatible with FPS games (you're better off with a standard five-button mouse), but being able to control X and Y axis movement with one hand is seamless, and makes playing flight sims with a keyboard and mouse nearly as easy as using a regular joystick.

I've spent a little time with the Pu94 since E3 ended, and I like building homes in *The Sims 4* a lot more. I'm able to fully customize the mouse controls to the game—and let me tell you how much more I enjoy tilting the mouse to pan across the screen instead of moving my mouse cursor over to the side or using the arrow keys. And instead of right-clicking to rotate objects, I use the thumbstick. Sometimes small things make all the difference.
$129, https://lexip.us

© LEXIP

KILL-A-WATT EZ

How much power is your PC using right now? You probably have no idea, unless you're using something like P3's Kill-A-Watt. It's a super-handy device that I've had in my arsenal for years. It's also inexpensive, and can easily pay for itself by helping you cut down on power use. Our modern PCs have sleep modes and power-saving features, but fire up a game, and it can be surprising just how much juice your system drinks. My GPU test bed idles at 72W, but can draw over 500W while playing games with a 2080 Ti, depending on what CPU I'm running. I also discovered that setting my Nvidia card to "Prefer Maximum Performance" instead of "Optimal Power" caused it to draw about 45W more power at idle.

The Kill-A-Watt measures outlet power, which is what most people want to see. It won't tell you power-supply efficiency or how much energy just your graphics card uses, but switching from a generic PSU to an 80 Plus Gold unit should cut your PC power use by 10–15 percent. It's not just about PCs, either. That box fan in my bedroom uses 60–100W, depending on the fan speed, while my upright vacuum cleaner chugs 1,100W. And do you remember the Falcon Northwest Mach V that I tested back in March? It peaked at over 950W while gaming.
$20, www.p3international.com

GEEK TESTED & APPROVED

V-MODA Crossfade II

YOU MIGHT NOT have heard of V-MODA. That's OK; you're about to. Italian design marries Japanese engineering tech, producing some of the highest-quality audio gear we've seen. Its latest headset, the Crossfade II, is no exception. As the box says, "Veni, Vidi, Vici." It came, saw, and conquered, pumping out top-quality bass and clarity, thanks to unique dual-diaphragm drivers and coils that support high-res audio sources.

It's wireless, too, boasting an impressive 14-hour battery life and simple buttons for volume and call control on the right headphone. A Qualcomm audio codec ensures sound quality is preserved over Bluetooth, and passive sound-damping tech means you can blast some tunes on the train without disturbing everyone around you. If you're really craving that zero-latency performance for gaming, the Crossfade II also comes with a cable for wired use.

It's really comfy, too. The headband is adjustable on both sides, and the earpieces use squashy memory foam cushions to keep your ears cozy. The box also contains a groovy hardshell carry case with a carabiner attachment to transport the headphones around.

V-MODA produces custom-made shield plates for the earpieces, too, which are 3D-printed and laser-engraved for complete design freedom. Choose from one of V-MODA's designs, or submit your own, as we've done. **–CG**
$330, www.v-moda.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Ryzen 3000 Purchases
> Optical Drive Noise
> AMD Blu-ray Support

Buy Now?

I am in the throes of building a new system, and have a question on the next generation of Ryzen processors. Is it worth the wait for the new Ryzen 3000, AMD X570, chipset, or should I go forward with the AMD X470 chipset, Ryzen 2700X, and upgrade the CPU later? The machine will be handling moderate gaming, moderate photo, and everyday use. Also, what components would be potentially affected by the new AMD X570 chipset?

–Thom Mason

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: At the time of going to press, Ryzen 3000 still hasn't been released, and we're waiting to get test samples so we can see if the reality can live up to the hype. We suspect it will, though, and from what we've seen so far, it's going to shake the desktop PC market up significantly. The shift to PCIe 4.0 is the big sell for the X570 motherboard, which will see storage performance improve significantly, as well as ushering in potentially better graphics performance—but initially don't expect too much from a gaming perspective. So, we'd definitely wait until Ryzen 3000 comes out, which leaves us with the question of which model you should buy, and this we honestly can't say at this point, as it really does depend on the performance on offer from each. If we had to make a recommendation, the Ryzen 7 3700X looks like the best bang for anyone's buck right now.

Spin Cycle

Is there a way to reduce the CD/DVD-ROM drive rpm when playing DVD movies? Some DVD movies play at extremely high rpm, causing the drive to make a lot of noise. **–Wayne R.**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: There used to be several tools that would help with this, but given the declining popularity of optical media and drives in machines, these seem to have fallen out of favor. There used to be a such a tool in Nero (remember that?), by the name of NeroDriveSpeed, and if you search around you should be able to find it in an archive somewhere, although we have no idea if it works, as we don't have a machine with an optical drive to hand. If the problem persists, you may find that your drive is faulty, in which case replacing it may be your best bet. Looking at Newegg, a replacement can be had for around $25.

AMD 4K Blu-ray

A couple of issues ago, you tackled a letter from a reader who was trying to build a rig capable of playing 4K Ultra HD Blu-ray discs. At the time, the only CPU capable of doing the decoding was a specific Intel processor. Since then, I've heard rumors that certain Nvidia GPUs are capable of offloading the decoding, and it shouldn't matter what CPU you use. I'd like that to be true, as I have my heart set on a Ryzen chip for my next build. Do you have any inside knowledge?

–Bill Wheeler

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: Unfortunately, not much has changed when it comes to Ultra HD Blu-ray playback, and to legitimately play your movies, you still need an Intel Kaby Lake or Coffee Lake CPU with Software Guard Extensions (SGX). There's a limited number of drives that work with it as well. You can find a complete list of supported hardware at www.cyberlink.com/support/product-faq-content.do?id=19860. The frustration is that there's no hardware reason why AMD's Ryzen chips aren't supported—it isn't to do with a lack of performance, but the DRM requirement is only solved by SGX.

Better than RAID

In the July 2019 issue, there was a feature called "Deep Into Storage Spaces." Great article about a relatively useless implementation of drive pooling in Windows 10 called Storage Spaces. That is, until you introduced the "Solid States" boxout—very cool. I immediately used an HDD and SSD to set up a tiered simple storage pool using the commands in the boxout. The article clearly states that working from new unformatted

↘ submit your questions to: comments@maximumpc.com

drives is best, but I used existing drives and deleted all partitions, which works just as well. However, the drives I used had GPT partition tables, which may be why I had difficulty defining the storage tier sizes. Max drive capacities (in my case, `$ssd, $hdd -StorageTierSizes 232GB, 4580GB`) didn't work. Once I realized that some of the drive was being used, I decreased the sizes by 2GB and 10GB respectively, and it worked. Once set up, I went into the GUI and optimized and expanded the pool. Also, advice to anyone following the boxout: Run `Get-PhysicalDisk – CanPool $True` to see all the drives that will be pulled into the pool. You may not want some of the drives in there, and if you don't, disable them before you run `$disks = Get-PhysicalDisk -CanPool $True`. Lastly, in the `New-StoragePool` command, I was unable to get it to run with `$disks`, but it did run with the singular `$disk`. Now Storage Spaces are smoking and, as advertised, "better than RAID."

–O.B. Schooley

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: Glad you enjoyed the article, and found it useful. You're right—it's the boxout that makes actually doing it really worthwhile. You're also right that it should be singular: `$disk` not `$disks` for the `New-StoragePool` command.

Open Classic

In the June 2019 issue, in "Letters," you mentioned Classic Shell. Are you guys slipping? Classic Shell was picked up by Passionate Coder and renamed Open-Shell ages ago.

I install it on all my long-time Windows user friends' computers every time I help them upgrade to Windows 10. Check it out: www.majorgeeks.com/files/details/classic_start.html. Oh, and you do know Windows 10 upgrade from activated Windows 7 upward is still free? Keep up the good work! **–Mike**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: The original Classic Shell still works on the latest build of Windows 10 (1903), although Open Shell does seem to have been updated with a few more features, so stands on its own. To be honest, we haven't found ourselves needing to use these recently, as we don't find Windows 10's interface as horrendous as Win 8's, but it's good that projects like this still exist and are supported. And good work helping others upgrade.

Clipboard Sync

I'm writing about the "Sync Your Clipboard Across Multiple Devices" article in the June 2019 issue. My System Settings screen doesn't have a "Clipboard" tab. Methinks you're running the Pro version of Win 10, and I am out of luck, as I am running the Home version.... **–Alan Cohen**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: We've just checked on a variety of machines, some running Pro and some Home, and it's on all of them. The one thing we did notice from the screenshot you sent us was that your version of Windows is more out of date than our machines (you seem to be running 1803—the latest Windows Update takes you to 1903; the previous version was 1809). Update Windows, and you should find you can sync your clipboard with the rest of us.

Rural Connections

I read, with great interest, about Microsoft's Xbox One S All-Digital Edition. I understand companies wanting to make a profit, but let me plead the case of those of us who are outside a decent infrastructure of fiber optic or cable. Digital content for us rural folks will be very difficult and unreliable. I am on DSL (which I understand is viewed in the same regard as a dial-up modem), and our download speeds hover between 0.5 and 2.5Mb/s, or 3.0Mb/s on good days. I have a PlayStation 4, and every game I buy has to download a network file or game update, which takes hours. If I had to download the entire game, I'd be unable to use my purchase for two or three days.

Also, not having a physical disc places another burden on us. If, for some reason, we are unable to access the cloud server, our money is spent and we receive nothing in return. I was also informed by my Internet provider, that if I ever disconnect from DSL, I won't be able to reconnect, as they are phasing it out. Yet we still do not have any infrastructure to tap into.

In short, it will become financially burdensome and, in some cases, impossible to enjoy gaming.

And let's not get into satellite Internet. I have my own personal experience with that from my former job (it was horrible), and stories abound about unreliability, slow-to-non-existent speeds, and technical problems. **–Ben**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: It will be interesting to see how the All-Digital Edition fares (with no second-hand market, it may be a non-starter for those in cities as well). We do feel your pain, though, as your gaming experience doesn't sound fun, and not having Internet access does undermine the likes of Google Stadia, too. Maybe 5G will be the answer. No, we doubt that as well. Hopefully, there will be a solution at some point.

[NOW ONLINE]

PCI EXPRESS 6.0 PAVES WAY FOR FASTER SSDS AND GRAPHICS CARDS IN 2021

The standards body in charge of overseeing the PCI Express protocol is following an aggressive upgrade schedule. It will still be another few weeks before the very first consumer motherboards supporting PCI Express 4.0 (PCIe 4.0) arrive in retail, courtesy of AMD's Ryzen 3000 CPUs and X570 motherboards, but the body that oversees the spec is already looking ahead to PCIe 6.0.

PCI-SIG (Peripheral Component Interconnect Special Interest Group) announced this week what is essentially a draft spec for PCIe 6.0. What about PCIe 5.0? That's not being skipped—in case you missed it, PCI-SIG formally ratified a finalized PCI 5.0 spec in May.

Read the full article: https://bit.ly/2MYzXv2

UPGRADE OF THE MONTH

3TB SEAGATE BARRACUDA COMPUTE HDD

All right, we know—HDDs aren't sexy. This one is no exception; hold it in your hand, and it's little more than a heavy metal rectangle. But this HDD is particularly good value; a mere 80 dollars for three terabytes of storage, and we're using two of them in our turbo build. By comparison, if we wanted 6TB using the 2TB drives we were using previously, it would run us an extra $20 in total—plus the extra hassle of setting up cables to a third drive. As such, we feel pretty comfortable naming this drive (the ST3000DM008 model) our Upgrade of the Month. **$80, www.seagate.com**

AS YOU CAN PROBABLY TELL just by glancing at the table, we made a lot of adjustments to our turbo build this time around. Those adjustments have led to a bit of a jump in price, but the machine is better off for it. RTX 2080 GPUs have risen back to the $700 mark, so we decided to take the opportunity to shift over to MSI with its RTX 2080 Ventus 8G. We mixed up our cooling solution, too; it seems Cooler Master is the flavor of the month this issue, because its MasterLiquid ML360 enabled us to upgrade from 240mm to 360mm of radiator space—which can be fitted either to the top or the front of the NZXT H700i—for just five dollars more than the previous Kraken X52 cooler.

As expected, we also had to change out the PSU again, thanks to the constant price shifts, so we've gone with a reliable 850W model from Corsair this month. We also managed to scrape together a small saving by following the example set by the mid-range build, and switching over to G.Skill RAM, using a 32GB kit from the TridentZ RGB series at 3,200MHz. Our final change was an upgrade to storage—no longer content with four terabytes, we're upgrading to two of Seagate's 3TB BarraCuda hard drives. We also considered swapping out the Gigabyte Aorus RGB M.2 drive for a Patriot VPN100 of the same size, but ultimately decided that the drop in speed wasn't worth the potential saving.

For more of our component recommendations, visit www.pcgamer.com/hardware/buying-guides/

INGREDIENTS

PART		PRICE
Case	NZXT H700i	$185
PSU	850W Corsair TX-M Series 80+ Gold NEW	$100
Mobo	ASRock X399 Phantom Gaming 6	$250
CPU	AMD Threadripper 2950X	$830
Cooler	Cooler Master MasterLiquid ML360 RGB AIO NEW	$135
GPU	MSI GeForce RTX 2080 Ventus 8G NEW	$700
RAM	32GB (2x 16GB) G.Skill TridentZ RGB @ 3,200MT/s NEW	$170
SSD	512GB Gigabyte Aorus RGB M.2 NVMe	$120
HDD	2x 3TB Seagate BarraCuda Compute NEW	$160
OS	Windows 10 Home 64-bit OEM	$100
Approximate Price:		**$2,750**

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