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FROM PONG TO PORTAL AND BEYOND

FUTURE

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EDITORIAL

WELCOME TO ANOTHER ISSUE OF APC

EDITORIAL

2020 revision

Looking back to understand where we are now in tech.

Covid set the scene for a year in tech that saw crazy situations absolutely nobody could predict. The PC was suddenly even more important than ever, as we relied on our gear to work under ever-increasing stresses – as much as we also used our PCs to kick back and escape reality with gaming that took us to a better place for a short while.

Motherboards, the foundation that holds it all together, saw new generations from both Intel and AMD, as SSD speeds rocketed up – for AMD users, at least – as did prices, with premium boards now well over a grand. Even low and mid-range boards saw price creep. We also saw what appears to be the ultimate PC assimilation by RGBs, with the few remaining components previously not RGB-lit now fully adorned with the glowy goodness.

Advancements in graphics cards were welcomed by crypto miners and scalpers, who appear to be the only people able to actually buy these items. In their second-tier function as gamer products, graphics cards saw big speed bumps from both team Red and Green. In 2020 we also learned that MSRPs are completely meaningless. Still – if you scored an Nvidia 30-series or AMD 6000 series card you were in a gamer's happy place.

The flip-flopping of the decade-old David vs Goliath CPU battle continued through 2020, with AMD locking in its advantage over Intel and owning most of the market. Ironically Intel now offers some of the most compelling products in the lower end of the market, which was once AMD's space. But wait, Apple has a CPU now...?

As COVID hit and we all migrated from the office to our living rooms, the demand for nice new laptops and PCs went crazy. So it was a good thing that the industry delivered one of its nicest years ever in terms of improving the gear and making machines that are an absolute delight to work on.

As 2020 kicked off and stock ran dry and backlogs grew – the nation's resellers rose to the occasion. Many worked around the clock to meet the sudden avalanche of orders, and we saw resellers really shine when it came to communicating with shoppers about stock situations and their orders. It was a time when we truly were all in it together, and the shops we relied on became real heroes in this unexpected drama.

BEN MANSILL

"Ironically Intel now offers some of the most compelling products in the lower end of the market, which was once AMD's space. But wait, Apple has a CPU now...?"

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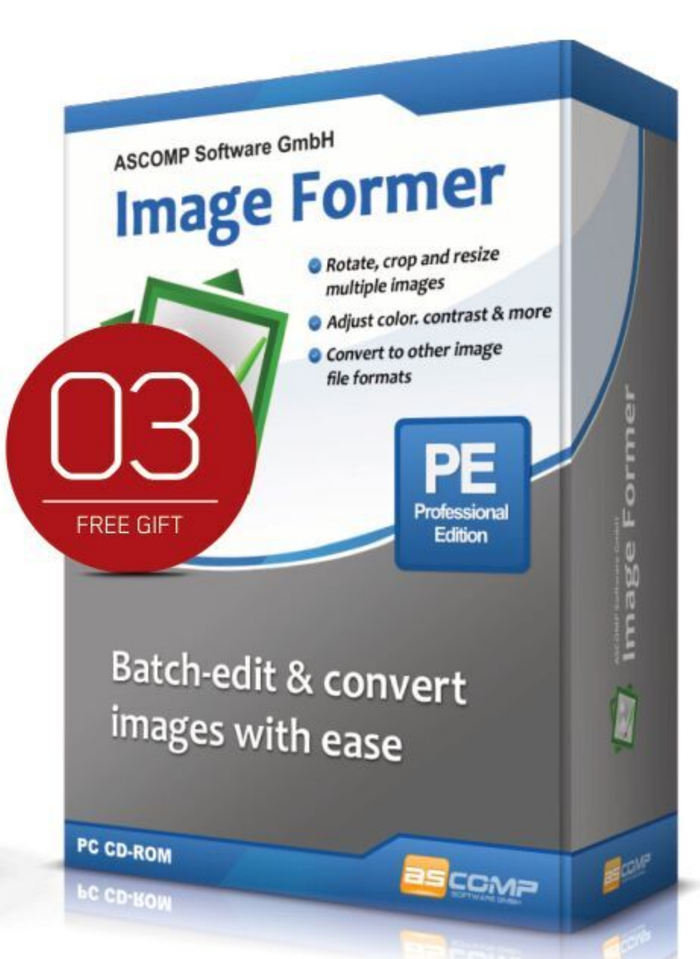

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Ashampoo WinOptimizer 2021

Effective enhancements for a faster, leaner and more secure Windows.

Ashampoo WinOptimizer 2021 is a customisable Windows cleaner and accelerator. You decide which applications and services auto-run with Windows. This helps you free up memory and speed up startup times. Privacy protection is another focus of the program, with the ability to significantly limit telemetry and data collection, a godsend especially for Windows 10 users! Ashampoo WinOptimizer 2021 includes a total of 23 modules to boost and customise Windows systems.

The program also analyses your OS and hardware, wipes or encrypts data and helps with file recovery. User rights and power scheme management is also included.

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Inside *APC*

Find out all about *APC*'s editorial policies, test practices, how to read the benchmark results, and more.

APC is Australia's oldest consumer technology magazine – having been consistently in print for forty years, since our first issue way back in May 1980 – and we take that heritage and responsibility very seriously. While our focus is obviously on the personal computer the very definition of the PC has changed and shifted markedly since the early 1980s. As such, we touch on many other areas of tech, too, from smartphones and apps to peripherals, accessories, and beyond. We have two goals: to find the best modern tech and to help you make the most of it.

We're also an open church in terms of platforms. We know most people aren't wed to a single brand's products and use a variety of devices. And, like you, *APC*'s journalists want to know what's good in tech – no matter what platform it resides on.

Independent reviews

Championing technology doesn't mean we're unrelenting yes-men and -women, however, and *APC* aims to be as objective as possible in all our coverage. That means identifying the best products from multiple perspectives – the best performance, best value and best features and, ideally, the products that offer the best mix of these three attributes.

As a matter of policy, reviews published in *APC* are not shared with product-makers prior to print. We will contact vendors under certain conditions; for example, if we have a problem testing a product that seems to indicate it may be faulty, or to invite a vendor to clarify how a particular feature works. If an *APC* reviewer has any potential conflicts of interest involving a brand, the review will always be assigned to another writer.

Labs testing

APC strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible. We use a variety of tools and programs for this, including many freely available benchmark suites for assessing media encoding, general system performance including storage read and write speeds, gaming and battery life.

In most cases, for the benchmark results published in *APC*, you can assume that higher is better. There are certain tests that deviate from this rule where the opposite is true; in those cases, we've flagged the results with a note explaining as such.

We use both tables and graphs for displaying results; the latter offers better ease-of-readability, but tables are more compact, so we use these in most cases where thoroughness is preferred. ■

APC testbed

The current *APC* testbed used in the Labs for benchmarking all components. This testbed is updated as new and relevant technology comes on stream.

CPU	AMD Ryzen 7 5800X
Motherboard	Asus ROG Crosshair VIII Dark Hero
GPU	MSI GeForce RTX 3080 Gaming X Trio
Memory	2x8GB Team T-Force Xtreem ARGB DDR4-3600
Primary SSD	Adata S70 2TB NVMe
Secondary SSD	Samsung 980 Pro 500GB NVMe
Cooling	Nzxt X73 360mm AIO
Case	Thermaltake Core P8
Power Supply	Corsair AX1000

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TECHNOTES

ALL THE NEED-TO-KNOW TECH NEWS

SPECIAL NEWS FEATURE

Windows 11: Everything you need to know

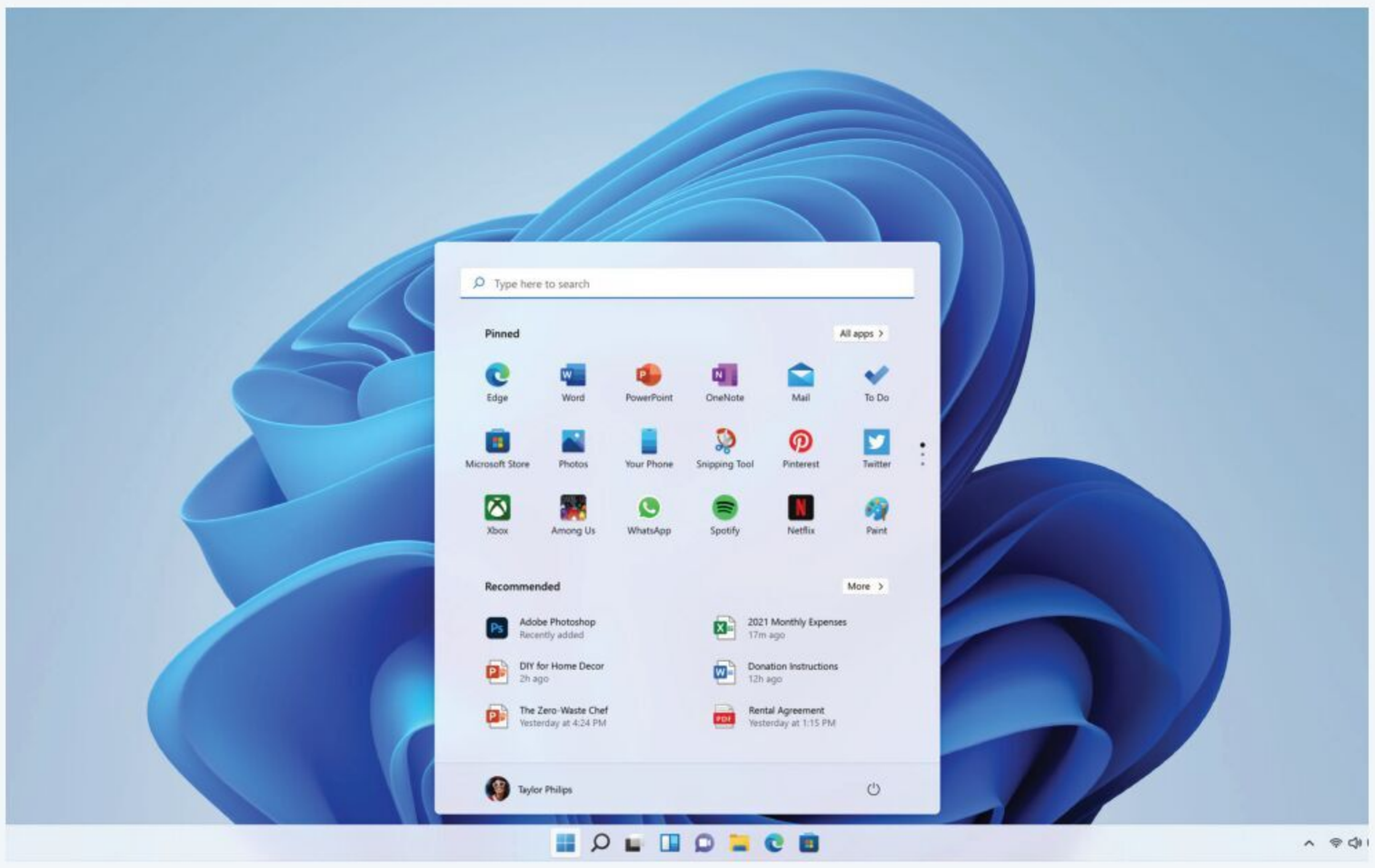
Microsoft's next OS has a slew of new features.

It's official: Microsoft has announced that the next version of Windows will be called Windows 11 and will be released as a free upgrade (and on new PCs) by Christmas 2021. Over the next few weeks and months, Windows Insiders will get to try out all the new features and we'll all learn more about what's in store. Here's everything you need to know about Windows 11 right now.

Insiders have it now, main release later in 2021

If you're signed up as a WIndows Insider, you should be able to try an official early version of Windows 11 by the time you read this, according to Microsoft. Microsoft says that anyone in the Dev or Beta channels will be eligible to get the Windows 11 Insider builds, provided that their hardware meets the requirements.

Windows 11 is ready to go right now, as long as you have an Insider account and meet the minimum machine specs.



To sign up or change your channel in Windows Insider, go to Settings->Update and Security->Windows Insider Program. Microsoft also says that the official upgrade will be rolling out by the "holiday season." So expect it any time between October and December.

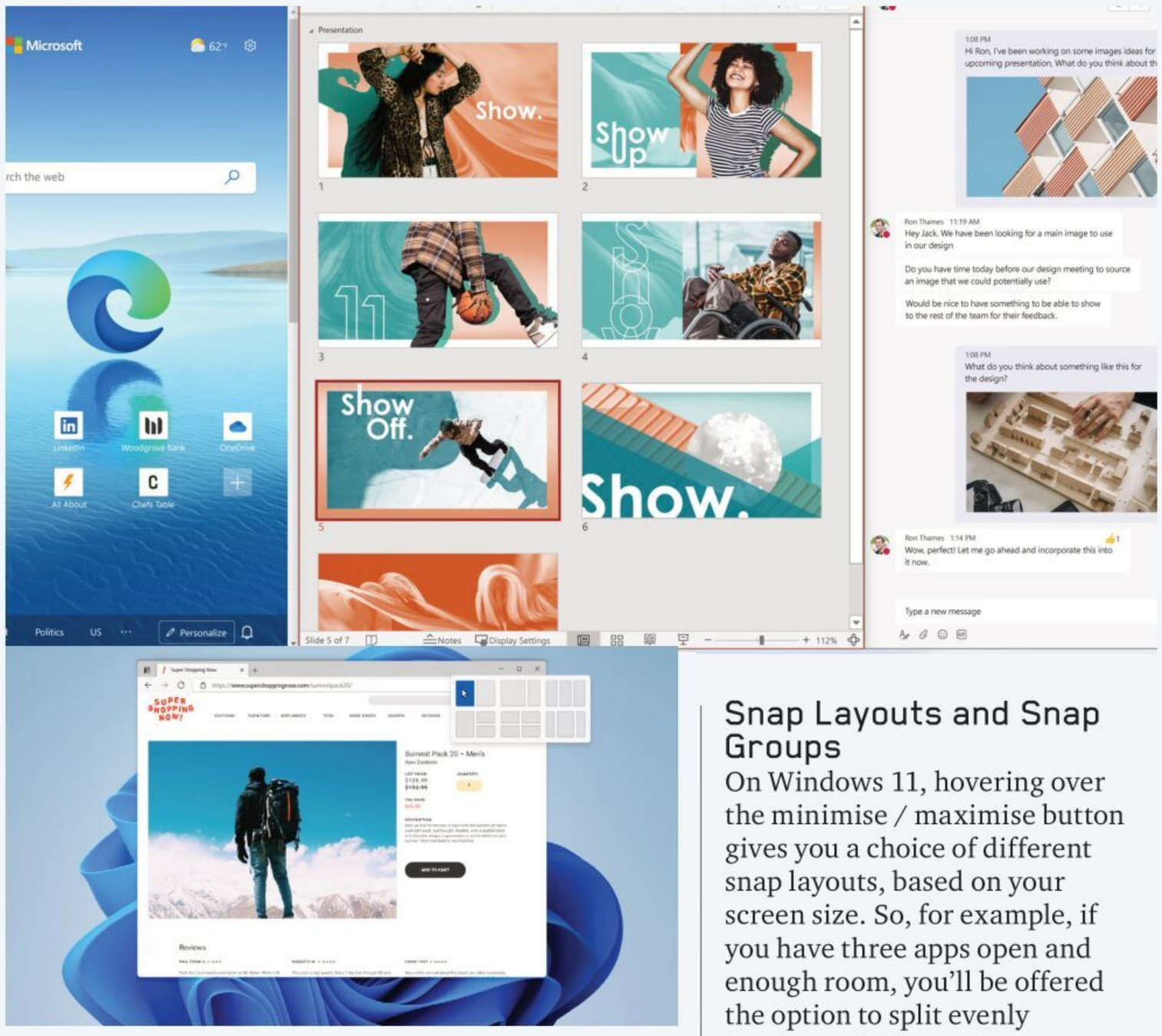
Free upgrade, list of requirements

Like Windows 10 before it, Windows 11 will be a free upgrade for anyone who has a recent prior version of Windows and the right hardware. According to Microsoft's blog, the minimum system requirements are:

- CPU: 1 GHz or faster with two or more cores on a 64-bit processor
- 4GB of RAM
- 64GB of storage
- UEFI BIOS with Secure Boot
- TPM 2.0
- 9-inch or larger screen with 720p resolution
- Internet connectivity and an MS account. No offline installs
- GPU compatible with DirectX 12

These exceed the Windows 10 system requirements in a number of ways. Microsoft lists those as 1-GHz CPU (but not dual core or 64-bit), just 1 or 2GB of RAM, a

Pics: Microsoft



Windows Snap gets a major overhaul, bringing good useability improvements.

mere 16 to 20GB of storage space and a GPU that is capable of DirectX 9 with a minimum resolution of 800 x 600.

The TPM 2.0 requirement could shut out some users, particularly those with home-built PCs. Not every motherboard comes with a TPM module on-board, though some motherboards are upgradeable with a TPM module you can buy after the fact. Many systems have TPM on board but it comes disabled so you'll need to turn it on your BIOS.

New Start Menu

The new Windows Start menu appears by default in the middle of the screen, though you can change a setting to make it appear on the left. Gone are the live tiles, replaced with simple, colourful icons.

Windows 11 sees serious Teams integration, which is welcome now, and would have been handy a couple of years ago.

According to Microsoft, the menu uses "the cloud" to help you as it shows recommended apps / documents, no matter what device you were working on previously. As an example, Microsoft Partner Director of Windows User Experience Carmen Zlateff showed how a document she was looking at on her phone appeared in the Start menu on her PC. Windows 11 also has a new Search experience, which now appears in a separate window (no more text search bar). It's supposed to also search across devices and services, as well as using Bing search for the web.

Snap Layouts and Snap Groups

On Windows 11, hovering over the minimise / maximise button gives you a choice of different snap layouts, based on your screen size. So, for example, if you have three apps open and enough room, you'll be offered the option to split evenly between all three or have one take up half the screen and the other two take up a quarter each.

If you have to interrupt your workflow by, for example, responding to an incoming email, you'll be able to restore your snapped layout by clicking on an icon on the taskbar. Icons for these "snap groups" will appear next to app icons so you can easily switch back to a complete layout in one click.

Docking and undocking: Windows 11 remembers

If you have a tablet or laptop that you dock to an external monitor and then undock, Windows 11 will automatically minimise the windows that were on the external monitor(s) when you disconnect from them and then automatically restore them to the monitor when you reconnect.

This is a huge win for anyone who has to take their laptop into a conference room for a meeting and then back to their desk after it's over.

Virtual Desktops now allow custom wallpaper

The virtual desktop experience has been improved so now each desktop can have its own wallpaper and distinct look. Zlateff said this is a good way to separate work from home and gaming experiences.

Teams integrated with Windows

The Teams icon will be on the taskbar and you'll be able to use it to make calls to anyone else who uses Teams on any device, including Android and iOS devices. You'll also be able to send and receive SMS messages from the taskbar.

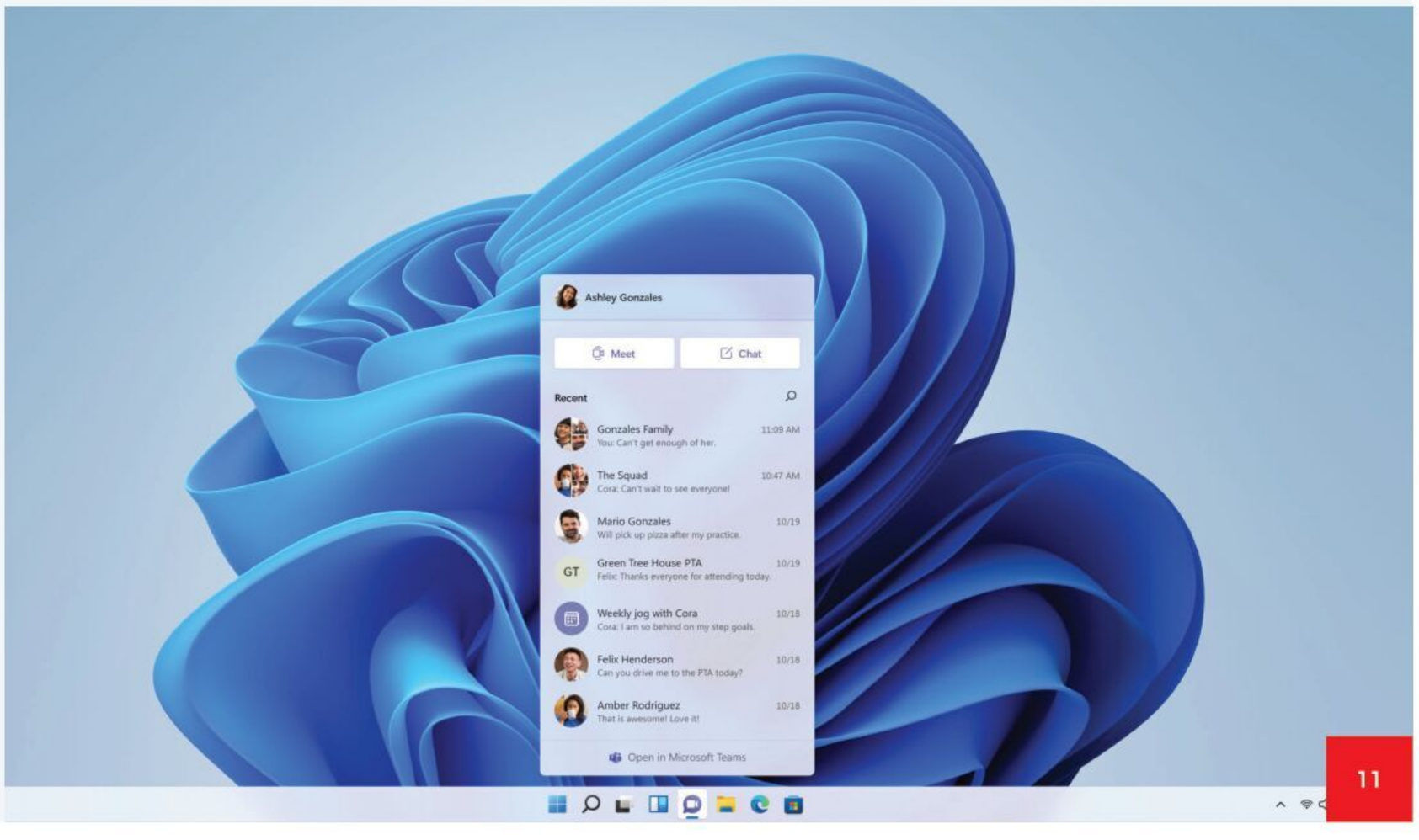
The news feed adapts to you, trying to bring in feeds that you want, based on your preferences. There's also a feature that lets you give some content creators a tip.

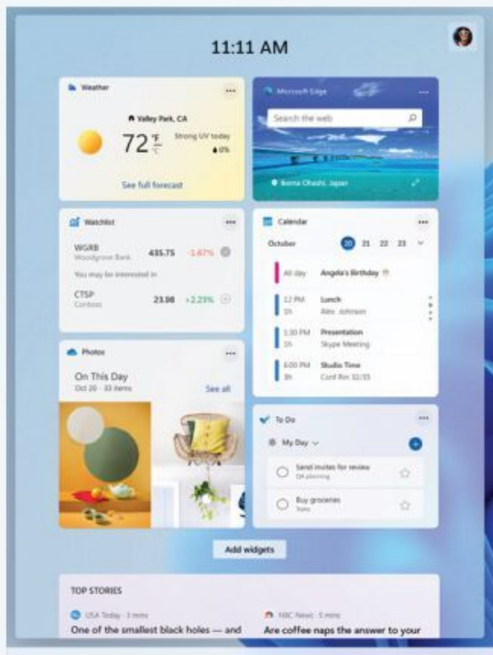
Windows Widgets

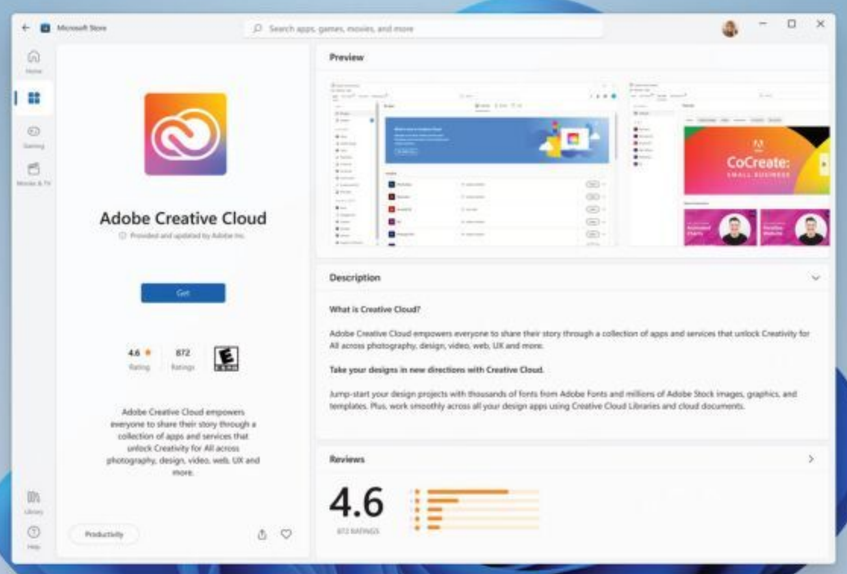
A slide-out pane on the left side of the screen shows you "Windows widgets" a set of curated news, weather and stock information. This is a clear evolution of the weather and news bar we see in recent versions of Windows 10.

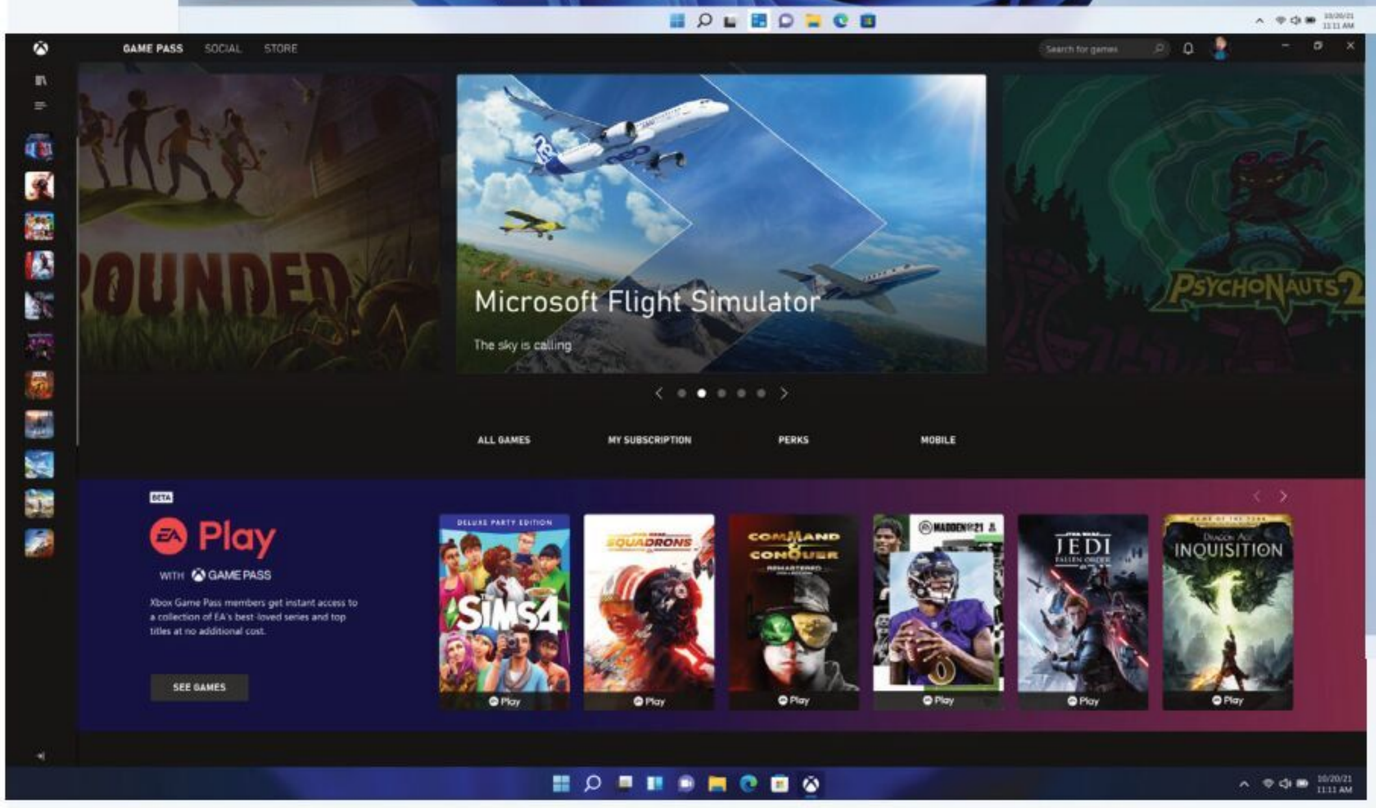
New touch experience

Say goodbye to "tablet mode." When you go into tablet mode on a 2-in-1, you'll see slightly more space between icons and larger touch targets, but the interface will remain largely the same. You'll be able to use the same gestures – three finger swipe for









example – that you use on a Windows Precision touchpad as well.

The pen experience has been updated to allow haptic feedback as you write. The touch keyboard is all-new and will let you customise its look and feel while also using emojis. Voice typing has also been improved and automatically adds punctuation while taking voice commands such as "delete that" to help you edit.

Auto HDR for gaming

If your monitor supports HDR but your game doesn't, Windows 11 will convert the colour and lighting. During a demo, Microsoft's Sarah Bond showed how this feature made Skyrim look much more colourful and lifelike. This feature originated on the Xbox and is now coming to the PC.

DirectStorage helps load times

Another Xbox feature now bound for Windows, DirectStorage allows your game to load content directly from your NVMe SSD into your GPU's memory, without using a lot of CPU resources. This means faster level load times and less time spent waiting.

Xbox Game Pass built in

Xbox Game Pass will come built into Windows 11 so, if you purchase a membership, you'll have access to hundreds of titles. Xbox Cloud Gaming will also be available so you can even play on systems that have lesser hardware.

New Microsoft Store policies

The store will support all kinds of apps, including those programming as PWA, UWP or Win32 formats. If you use your own commerce engine, you will not have to pay any revenue share to Microsoft at all. However, if you use Microsoft's engine, you'll have an 85/15 split for regular apps or 88/12 for games.

Android apps coming to Windows 11

You will be able to launch Android apps directly within Windows and find them in the Microsoft store via Amazon's own app store. Windows will use Intel's Bridge Technology, a run-time post compiler, to allow the Android apps to run natively and be treated like any other Windows app that you can snap, pin-to-start, etc. Panay demonstrated this feature by running TikTok.

TOP LEFT: Widgets are back, and while potentially cool it open up new ways for Microsoft and partners to force feed us marketing.
TOP RIGHT: Unsurprisingly, Windows Store has seen a major revamp.
ABOVE LEFT: Windows Store also gets a new layout.
ABOVE RIGHT: Android integration too!

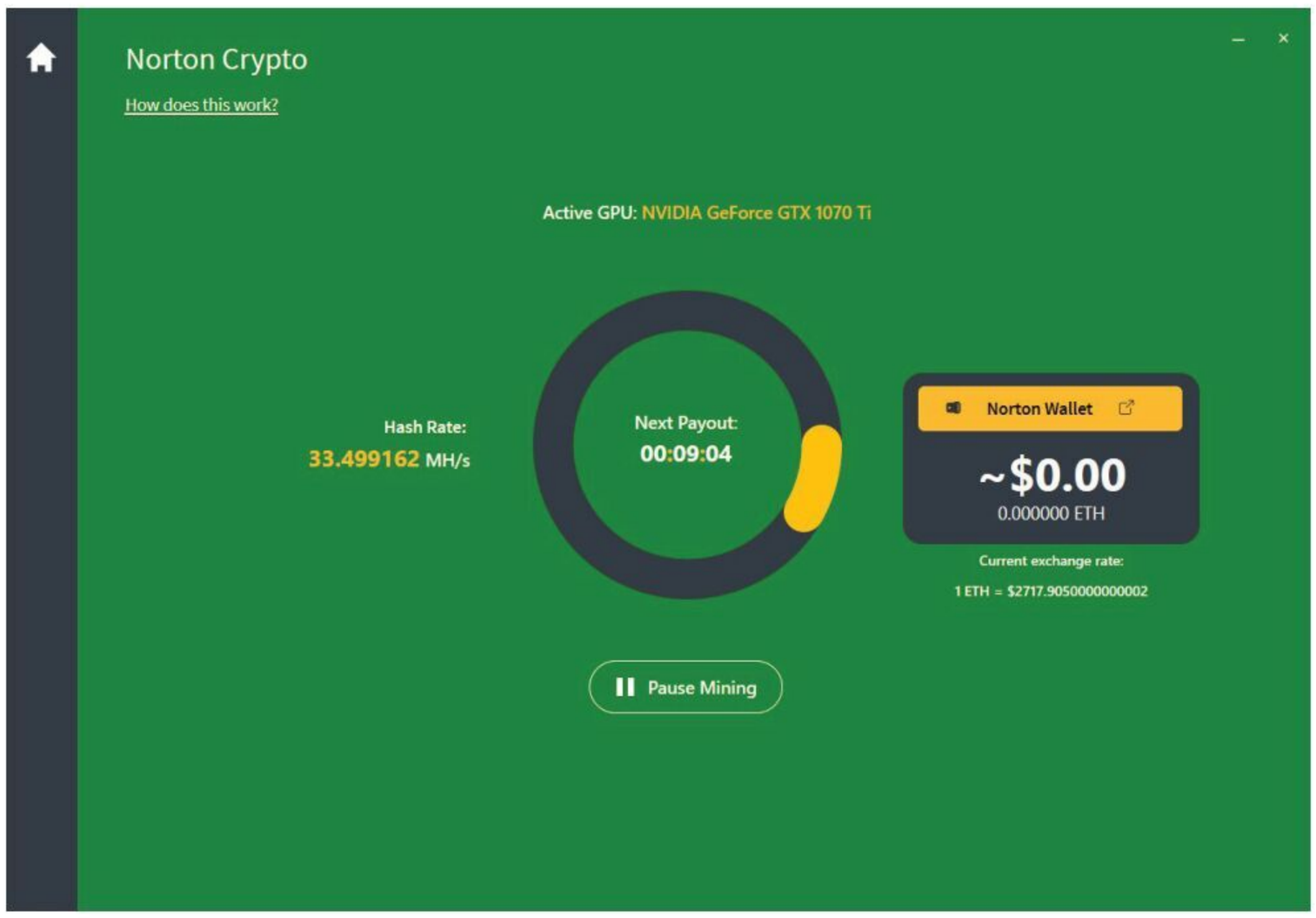
Yes, this technology will work on both AMD and Intel CPUs. Intel writes that "Intel Bridge Technology is a runtime post-compiler that enables applications to run natively on x86-based devices, including running those applications on Windows." More importantly, on a later broadcast, Microsoft Head of Developer Platform Kevin Gallo confirmed that this "Android subsystem for Linux" would run on both brands of processor.

Windows 11 ready PCs

Get ready for the marketing blitz. Microsoft says that "Windows 11 ready" PCs are coming. Considering that the hardware requirements are so low that pretty much any new PC can meet them, this sounds like more marketing hype than useful information.

We have already received updates from Acer and Dell saying that either all of or the vast majority of their recent offerings are Windows 11 compatible. Suffice it to say that if your PC has less than 4GB of RAM and a sub-1-GHz processor, Windows 10 probably isn't working very well for you either. However, we don't know if all of these computers came with TPM 2.0 modules on their motherboards.

Pics: Microsoft



CRYPTO

Norton adds crypto mining capabilities to antivirus software

Ethereum mining for the family PC.

NortonLifeLock announced that it's adding Ethereum mining to its Norton 360 antivirus software with an upcoming feature, Norton Crypto, that "select Norton 360 customers in Norton's early adopter program" are invited to test.

Let's make this clear from the start: Enthusiasts will probably be better off learning how to mine Ethereum themselves instead of relying on Norton Crypto. The feature is likely intended for the kind of person who's never heard of a hash rate, shopped for the best mining GPU, or wondered how to optimise their GPU for Ethereum mining. It's worth considering how Norton Crypto is presented to those people.

Naturally, Norton positions Norton Crypto – and the accompanying Norton Crypto Wallet – as the solution to those concerns. The former is a mining tool built into antivirus software people already trust; the latter is a cloud-based solution to which people can transfer their earnings "so it cannot be lost due to hard drive failure." It's not hard to see how the feature could appeal to the (barely) crypto curious.

Microsoft to turn old Xbox Ones into cloud streaming boxes

The days of obsolescence may be over.

The Xbox Series X's cutting-edge hardware is intended for games that are slated only for new-gen consoles. Where does that leave owners of original Xbox One, which is starting to get a bit long in the tooth? There are still millions of users on the original Xbox One, which are barely capable of 1080p. That could be about to change.

In a blog post on Xbox Wire, Microsoft stated its intent to bring some cloud streaming goodness to older consoles to help them keep up. "For the millions of people who play on Xbox One consoles today, we are looking forward to sharing more about how we will bring many of these next-gen games, such as *Microsoft Flight Simulator*, to your console through Xbox Cloud Gaming, just like we do with mobile devices, tablets, and browsers." ■

Windows 10 to lose support in 2025

Four more years.

Microsoft confirmed that Windows 10 will stop receiving support on October 14, 2025, giving the operating system another four years before users must transition to a new version of Windows.

Breaking tradition, Microsoft revealed the end date for Windows 10 Home and Pro in a support document. The page previously contained vague phrasing, stating the date was for "when specific Windows 10 versions would leave support." It now seems both major versions of Windows 10 will be retired in late 2025, paving the way for a new edition.

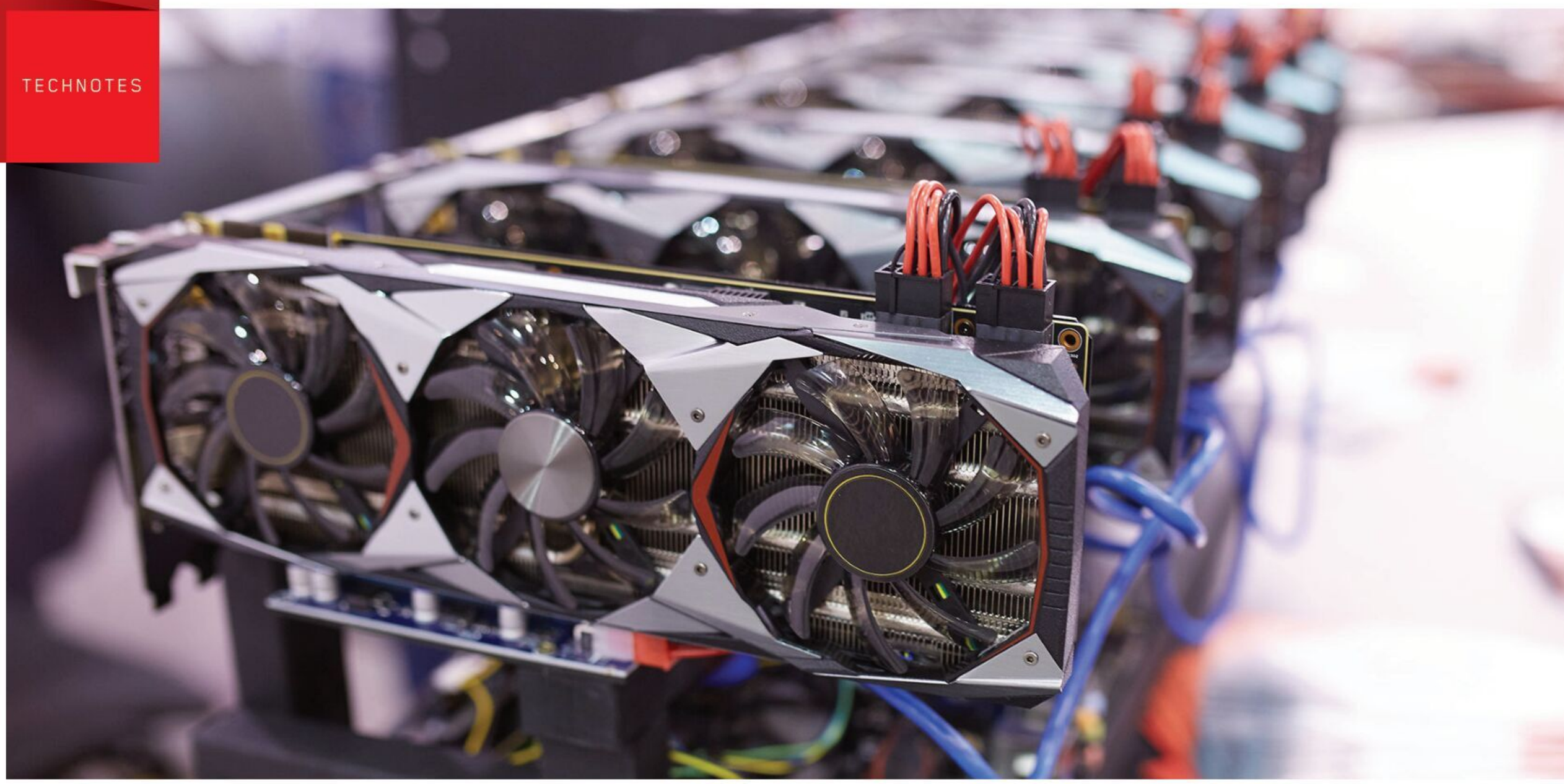
This is not a surprise. Back when Windows 10 was new, Microsoft confirmed that it would continue its traditional 10 years of support for Windows 10.

HP get gamier

Completes purchase of HyperX.

Along with its Omen gaming range, HP can now call HyperX home, after the US$425 million acquisition was wrapped up last month. HyperX was formerly a brand under Kingston, and includes memory products and gaming peripherals, including the highly-regarded Cloud headphone series.

Kingston, in turn, announced on the same day the launch of a new gamer and enthusiasm performance memory brand under its wings: 'Kingston Fury'. Unlike the HyperX brand, which had a diverse collection of products, Kingston Fury will concentrate solely on memory products, at least for now. Expect three tiers of Fury memory: Renegade for enthusiasts, Beast covering "high-performance, cost-effective upgrades", and Impact SO-DIMM products for laptops and NUCS.



TECH BRIEF

700,000 GPUs shipped to cryptominers in the 1st quarter of 2021

Miners making it rain.

In a new report, Jon Peddie Research sheds some insight on the impact that cryptocurrency mining has had on AIB (add-in board) sales for the start of this year. Needless to say, AMD, Nvidia and their AIB partners have profited hugely from the high demand on the best graphics cards.

The consulting firm estimated that 25 percent of the graphics cards shipped in the first quarter of 2021 went into the waiting grubby hands of cryptocurrency miners and speculators. That's roughly 700,000 high-end and midrange gaming graphics cards. In monetary terms, we're looking at a hefty sum in the range of US$650 million.

Jon Peddie Research, who has tracked AIB shipments since 1985, noticed a substantial drop in the attach rate of AIBs to PCs. The firm observed the attach rate stoop as low as 25 percent before eventually bouncing back up to 50 percent. Jon Peddie Research then utilised a simple formula where the mining use of AIBs is equivalent to the difference between the trending normal attach rate and the existing attach rate.

The company used the assumption that serious cryptocurrency miners have their dedicated setups and purchase graphics cards. On the flipside, there are also casual miners who might invest in a complete system just for mining cryptocurrency. The firm admitted that its forecast model isn't as precise as before due to the shortage of components. We've already witnessed scalpers and miners that employ buying bots to purchase graphics cards before flipping them on eBay.

Cryptocurrency miners aren't the only reason for the drastic inflation in graphics card pricing. The pandemic also played a big role in this situation since it forced many factories to temporarily shut down and interrupting supply chains in the process. It's been known that graphics card components, such as GDDR6 memory chips, voltage regulators, capacitors, and other parts, have also gone up in price since the start of the pandemic. Jon Peddie Research measured an increase of up to 70 percent early in the year.

Currently about a quarter of all gaming graphics cards that hit the market end up with crypto miners.

AMD and Nvidia are basically untouched in our GPU benchmarks hierarchy, but the two companies are taking different stances toward cryptocurrency mining. For starters, AMD doesn't have any problems with consumers mining on its RDNA 2 (Big Navi) graphics cards. Nvidia, on the other hand, has launched its Cryptocurrency Mining Processor (CMP) line that's dedicated to Ethereum and cryptocurrency mining, and at the same time implemented an anti-mining limiter on most of its GeForce RTX 30-series (Ampere) graphics cards. The RTX 3060, RTX 3070 Ti, and RTX 3080 Ti all launched with a hashrate limiter in place, while the RTX 3060 Ti, RTX 3070, and RTX 3080 are being phased out and replaced by LHR (Lite Hash Rate) variants.

Despite both chipmaker's efforts – or non-efforts in AMD's case – graphics cards remain sold out everywhere. The little stock left retails for absurd prices. The second-hand market is even worse, as Ampere and Big Navi GPUs sell for 2X to 3.5X more than MSRP according to our GPU pricing index. Simply put, it's a bad time to buy a graphics card (for gaming). ZHIYE LIU ■

"Cryptocurrency miners aren't the only reason for the drastic inflation in graphics card pricing. The pandemic also played a big role in this situation since it forced many factories to temporarily shut down and interrupting supply chains in the process."

Pic: Shutterstock

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OPINION

APC'S EXPERTS COVER THE HOT TOPICS

END USER

Facebook's vision for VR is coming to fruition – via ads

It's receiving blowback, but you better believe it's here to stay, writes Shaun Prescott.

What is a modern computer user interface without sweet, sweet display ads? A utopian dream, of course. When Facebook surprise-acquired Oculus VR in 2014, the former's interest in VR was bracing, albeit kinda obvious upon reflection: for a company that profits from user data, it makes a lot of sense to acquire technology with unique data capture capabilities unavailable on smartphone or desktop. Not to mention that, while VR tech has always been discussed as a predominantly gaming-centric tech, the social media possibilities are enormous.

As elegant (albeit dystopian) as those motives seem, in 2021 Facebook's involvement has most obviously manifested in – you guessed it – ads. We saw it coming: when Facebook issued the Oculus Quest 2 last year, critics and users were united on the point that it's an incredible piece of tech at a good price point, but that price point was naturally complemented by one important caveat: you need to have a Facebook account to use the unit. This happened despite former leader and founder of Oculus, Palmer Luckey, insisting in 2014 that that would never happen.

Things change and you never take these people at their word, but if the requirement for a Facebook account rustled some feathers, moreso did the announcement in June that Facebook would begin testing display ads within Oculus Quest games and apps. If you were hoping to escape the mundanity of modern life by diving into, say, *Blaston* – a first-person action game you have to pay to play – then you'd better be prepared for laser-focused display ads based on your Facebook network interactions – stuff like what you've viewed, bought, installed, and other ads you've interacted with. On the other hand, it won't use information such as "weight, height, or gender information that you choose to provide to Oculus Move."

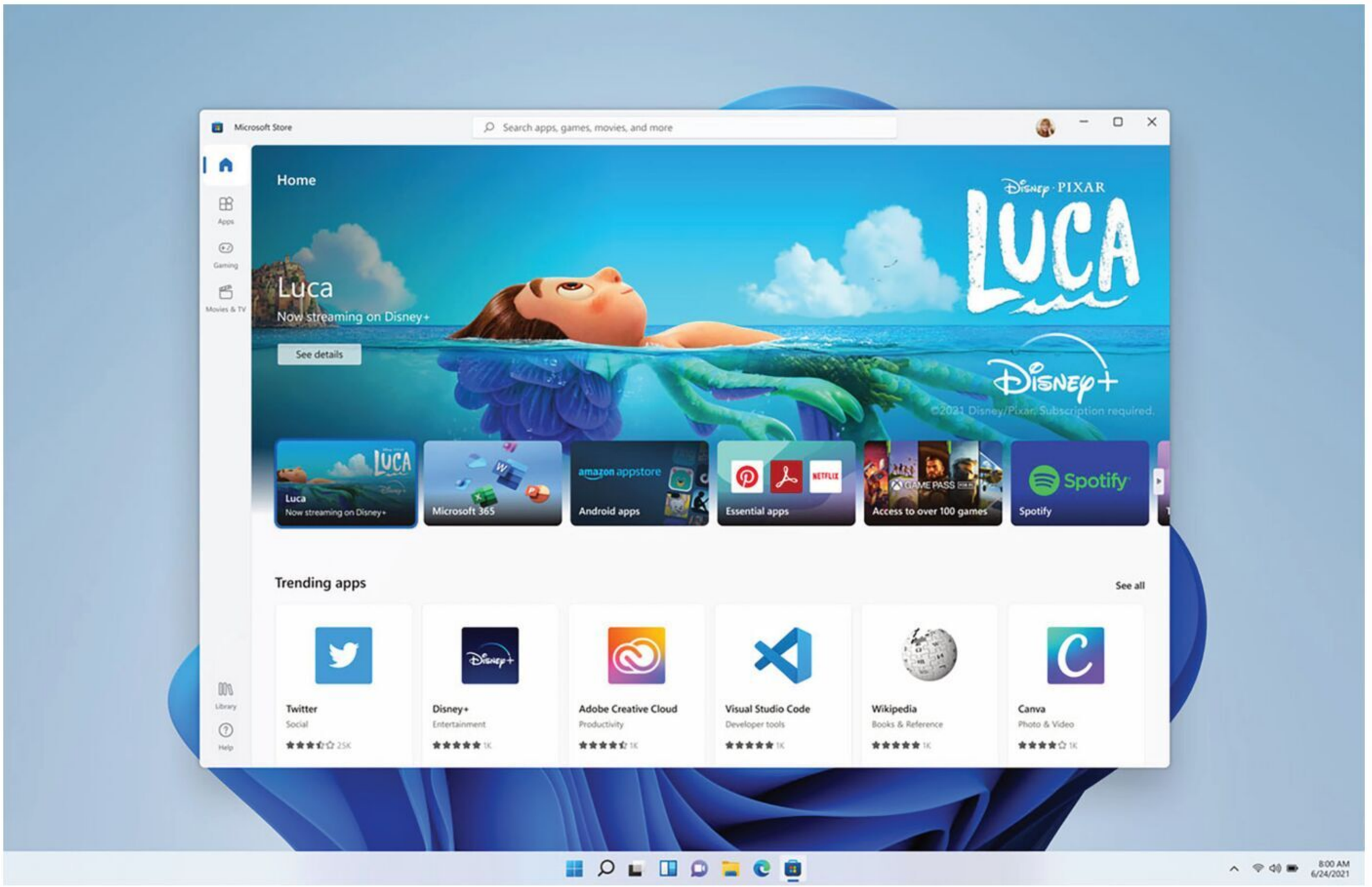
Blaston's fanbase review-bombed the game into oblivion shortly after these ad tests were rolled out, which appeared in the form of display ads on in-game monitors. The blow back was so severe that developer Resolution Games quickly removed them (it will return to the concept, a spokesperson said, with its next free-to-play game *Bait!*). But don't take this small victory to heart, because whether you like it or not, you're getting ads on Oculus Quest 2 apps.

It's just another example of brilliant tech falling afoul of the imperatives of modern surveillance capitalism. Like social media, it's not the platform that's at fault, it's not the technology, it's the people who control it. The entertainment you use to unwind after nine hours at the grindstone, the entertainment you spend money to engage with, is trivialised by Facebook's imperative to grow. And because Facebook has the money to issue VR headsets at a loss in order to exploit its data-centric advertising business, it's able to set the tone for the platform's future.

Let's hope other players, like Valve, have different ideas, but if you're tempted to buy into Facebook and Oculus's VR ecosystem, you better believe that you're going to be marketed to ad nauseum. ■

SHAUN PRESCOTT
Author, PC Gamer editor and passionate technology observer, Shaun covers trending tech topics for *APC*.

"Things change and you never take these people at their word, but if the requirement for a Facebook account rustled some feathers, moreso did the announcement in June that Facebook would begin testing display ads within Oculus Quest games and apps."



RANDOM ACCESS

Windows Shopping: do we really want Windows 11 to be 'free'?

On the day of its successor's announcement Joel Burgess muses on the driving forces of Windows 10 and what may continue into Windows 11.

When Windows 10 was released, Microsoft announced that it would, for the first time, allow users to upgrade from Windows 7 or 8.1 for free anytime within the first year. When 2016 rolled around this complimentary upgrade offer didn't end and even now in 2021, if you have an old Windows OS key you can use it to update the PC to Windows 10. The initial extension was framed as simply a more generous window of opportunity, but eventually journalists gave up asking when free upgrades would stop and Microsoft managed one of the softest launches of a 'free product model' we can think of.

In order to make up some of the revenue Microsoft lost by offering the $225 Windows 10 Home OS upgrade for free, the company started dipping its toes into the data collection space by pushing its users towards the web. There were a few ways this was done. The first stage was integrating web searches into the Windows Taskbar Search Box, to push more queries through the Bing web search tool. Instead of being helpful, this 'feature' generally means it takes twice the effort to find the app or folder you're looking for on your PC.

Later in May of 2019, Microsoft updated its Windows 10 Home OS to mean you needed a Microsoft account to perform the initial OS setup on a PC. There are hoops you can jump through to create a local account, but they're not obvious and make it look like creating a Microsoft account is the only option. This allows Microsoft access to your location activity, Cortana and speech activity, browsing history, search history, app activity and media activity.

It also binds PCs to users so that information about people with more than one device is more accurate for advertising purposes. Considering Windows 10 runs on 1.5 billion PCs worldwide, if utilised properly this data has the potential to make up the lost revenue from a free OS on its own.

Finally in 2020 Microsoft released its Chromium-based Edge browser, an overhaul that improved its overall market share, but not by much. The main issues are that it prioritises advertising potential over usability by doing things like taking you to a curated landing page that tries to catch your attention with highly clickable news, instead of reopening pages from your last session. A lot of the other fundamental experiences also make you feel like the browser is pushing you to pages where Microsoft can serve you ads, rather than make it easier to get to where you want to go.

JOEL BURGESS
When not reviewing PCs for *APC* and writing our funny pages, Joel likes to ponder tech and how it's used.

The 'free model' is set to continue on Windows 11 with the company offering complimentary upgrades for any 'eligible Windows 10 PCs', indefinitely. There's no indication that any of the inconveniences mentioned above are planning on being rolled back, and Microsoft is even leaning in to some of them. For example, Microsoft's answer to people not using the Edge landing page enough is to bake it directly into the Taskbar as a set of widgets.

We'll let Microsoft tell you in its own surprisingly honest words what the true point of the new Widget bar is: "Widgets also opens new real estate within Windows to deliver personalised content. Our aspiration is to create a vibrant pipeline for global brands and local creators alike, in a way that both consumers and creators can benefit."

Ads piped directly into the most used bits of your operating system… How great! ■

Pic: Microsoft

TWO BITS

3D stacking: The next frontier for chip technology?

AMD's V-cache technology is a big step forward.

Computex may have been virtual in 2021, but that didn't stop AMD from making a big splash during its keynote. On top of the announcements of its Ryzen 5000-series APUs and its long awaited FidelityFX Super Resolution tech came the announcement of its 3D V-Cache stacking technology. It was more than an announcement though – AMD demonstrated the technology, indicating that we could see a Zen 3 refresh incorporating V-Cache as soon as this year.

AMD has been on a roll over the last few years. The company released HBM GPUs, multi-chip module and chiplet processors, and now it's taking the next step in its 3D packaging journey. Stacked cores may not be here yet but stacked cache is. AMD CEO Dr Lisa Su demonstrated a Ryzen 5900X prototype with 192MB of L3 cache, a 3x increase from the standard 64MB of the 5900X.

The design incorporates a separate 64MB die atop an 8-core complex with its 32MB of L3 cache. The dies are connected though direct copper-to-copper bonding. AMD claims that this cache has a total bandwidth of 2TB/s. To demonstrate the gains on offer, AMD showed a selection of games, comparing both the standard 5900X and the prototype 5900X with V-Cache. Both CPUs were clocked at 4GHz, with the result being an average 15 per cent uplift in gaming performance. We'd take these numbers with a grain of salt, but when you add this to the expected performance uplift we can expect from the Zen 4 architecture, plus things like 5nm and its expected power efficiency, and it's clear that AMD is well placed to compete against Intel's Alder Lake and Raptor Lake series of processors.

There are some unanswered questions though. AMD was keen to emphasise the gaming gains the technology offers, as it did with the move from Zen 2 to Zen 3. Not all workloads will benefit from such large caches. Power consumption woes aside, Intel is still very competitive with its relatively tiny L3 caches while remaining competitive in gaming.

Will enterprise workloads see much benefit? If they are coded to, of course, but have to wait and see just how real workloads react to such massive amounts of cache.

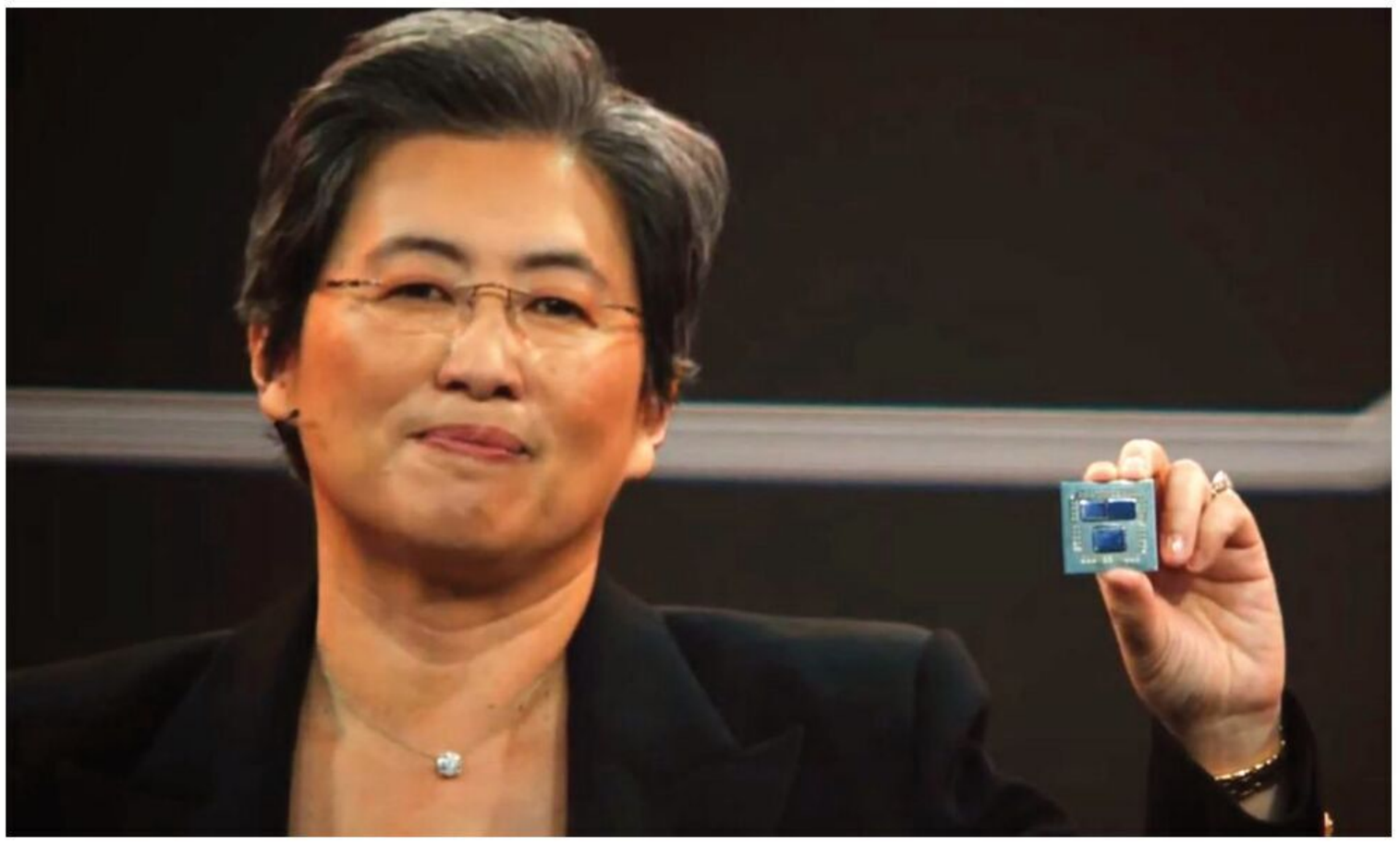
The possibilities on offer from 3D stacking are very exciting. How about an RDNA2 APU with 3D-cache? That could really elevate mobile GPU performance with only a minor power consumption penalty and remove DRAM speed as the bottleneck of its GPU performance. Would it be like Infinity cache on steroids? How about an Epyc processor with 192 or 256 cores or more? These are crazy numbers and the Googles, Amazons and Facebooks of the world will be lining up with chequebooks open.

Could true 3D stacked chiplets be something of a holy grail of processor manufacturing? It's well known that node shrinks are becoming more and more difficult. Dies are typically measured in the X and Y axis though. What about the Z-axis? If thermals can be controlled, then there's no insurmountable reason why we won't see core counts and cache sizes continue to rise for the foreseeable future. We could be looking at the first steps on an exciting new path.

We're really looking forward to seeing what Intel can do with Alder Lake and its Big/Little architecture shift. It may need to pull out something special to keep pace with an ever increasingly confident and innovative AMD. ■

CHRIS SZEWCZYK
A life-long PC tech enthusiast, Chris has worked acoss the industry in many areas as a product and technology expert.

"Stacked cores may not be here yet but stacked cache is. AMD CEO Dr Lisa Su demonstrated a Ryzen 5900X prototype with 192MB of L3 cache, a 3x increase from the standard 64MB of the 5900X."



TECH TALK

Goodbye mining, hello farming

The impact of chia is already being felt.

Just when you thought the cryptocurrency-induced PC component shortages couldn't get any worse, there's a new coin in town: chia. There's now a looming prospect of a cryptocoin that does to storage what ethereum has done to the graphics card market.

Chia coin officially went live on March 19, but the coin didn't start publicly trading on crypto exchanges until May 3. From a slow burn for the first few weeks, the amount of storage space required for the network (called netspace) ballooned from around 214PB to over 3.6EB – that's exabytes, or 3,984,588.8 terabytes. I shudder to think about how much netspace will be allocated to chia by the time you read this, given the current rate of increase.

But let's talk about what makes chia different. One of the big concerns with bitcoin, ethereum, dogecoin, and many other crypto coins is that they rely on proof of work. It's a race to solve a mathematical function that scales in difficulty. Bitcoin uses an estimated 13GW of power, or 14TWh per year – about as much as the Netherlands.

Chia, in contrast, uses proof of time and space, which should dramatically cut down on the amount of power consumed. On the other hand, it will chew up as much storage space as people are willing to throw at it, with a current default plot size of 108.9GB. Using 10TB hard drives, it would require about 360,000 drives for the current netspace. Assuming 5W of idle power use (the drives would mostly be idle), that's still 1.8MW of power, so bitcoin currently uses over 7,000 times as much energy. But if the netspace reaches 30EB or even 300EB, suddenly chia stops looking so green.

The proof of space element should slow down the rate of scaling. Where all that's required to bring a new GPU or ASIC online with proof of work hashing is powering the device up to start "mining," chia refers to its proof of space as "farming." Chia farmers have to generate plots that get filled up with what amounts to a complex bingo card. This takes a fast PC using a fast SSD about four hours for a single plot, but with the right hardware, it's possible to do a dozen plots concurrently in about eight hours. That means even if a big mining corporation wants to hop on the chia bandwagon and buys a few petabytes of storage, filling those drives up with chia plots could take several weeks.

Maybe it will end up as another flash-in-the-pan cryptocurrency. That's perhaps the best-case scenario. The worst-case scenario has started to play out in China, where SSD and HDD shortages are already happening. One SSD manufacturer attributes a 500 percent increase in sales in April to the demand from chia farmers, for example, and people online have reported seeing 400 percent increases in large HDD prices virtually overnight.

That will impact people who aren't trying to farm chia as well, and with SSD controller shortages prior to chia, we could see another perfect storm hit the PC industry. ■

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

"I shudder to think about how much netspace will be allocated to chia by the time you read this"

HOW IT'S DONE

TAKING THINGS APART AND HAVING A POKE AROUND

Xiaomi Mi Watch 2021

Fit for scheduled disassembly.

They say time makes fools of us all, but that hasn't stopped Xiaomi from working around the clock on a totally redesigned Mi Watch. Does its newest timepiece earn a place on your wrist? Tick tock, only this teardown can tell.

Major tech specs

- 1.39-inch (35mm) circular AMOLED display with 454x454 resolution
- 11.8mm thickness at 32g
- Wireless charging
- Accelerometer, gyro, heart rate, barometer, compass, SpO2 (blood oxygen testing)
- Water-resistant to five atmospheres
- Bluetooth 5.0

Key findings

- We're not seeing major changes in terms of hardware components over last year's square Chinese version of the Mi Watch, but the new design direction is evident. This watch even grew another button, perhaps to keep up with Samsung. Maybe there are only so many ways to shape something that straps to your wrist. Let's look inside….
- Even though it's water-resistant up to 50 meters, this Mi Watch opens with a Torx T2 bit from our Mako Driver Kit and a little prying. It's nice to be reminded that "waterproof" doesn't have to mean "glued together." Our first look inside is encouraging, too, as we spot some standard Phillips screws; though it would have been even better if only one screwdriver was needed.
- A bit of prying frees the battery. It's great to see this common repair prioritized, with a modular connector, no soldering required. The battery is a 1.62Wh (420mAh at 3.85V) Li-ion block, which charges wirelessly. Xiaomi claims it can power the watch for 16 days, or 50 hours during sports. The bottom part of the watch case also bears a cable assembly with a tiny vibration motor, the heart rate and SpO2 sensor array, a barometric sensor, and a MEMS mic. Behind the sensor board is a Texas Instruments AFE44l30 biosensor analogue front end module.
- Just two Phillips screws secure the mainboard – twist them out, and the board floats free. After removing the mildly glued-in button cable, we find an Ambiq Micro AMA3B MCU and a Bosch Sensortec BMI270 three-axis accelerometer/gyroscope on the top side of the board, while the bottom side features an STMicro STM32L4R9ZI6P microcontroller, Paragon PN26Q01AWSIUG 1Gb NAND flash memory, a geomagnetic sensor (likely), electronic compass, and an SGMicro SGM41562 Li-ion battery charger with power path management.
- It's been a pretty good experience so far, but here's the part we've been avoiding. To free up the display assembly, we had to use a heat gun at about 300 C and a razor blade, causing the screen some damage. We also gave playing cards a try, only for the display layers to separate. Then the actual screen shattered in our hands. The last things to come off are the two side buttons, held in place by tiny metal washers on the inside.
- Repairability Score: 5 out of 10 (10 is easiest to repair). The opening procedure is simple and glueless. Connectors are modular and don't overly overlap. The battery is easily accessible for repairs. Opening requires a somewhat uncommon T2 Torx driver, but Phillips screws grace the inside. Many components are grouped together and can't be replaced individually. Display removal seems impractical and repairs will probably require replacing the watch casing. ■

Last year's Chinese Mi Watch bore more than a passing resemblance to another watch made by a certain lifestyle company in Cupertino. With this version, Xiaomi has switched to an all-new, circular design.

It's usually difficult to repair the screen of a smartwatch that opens via the back, and the Mi Watch is no exception.

Top Left: With no soldering keeping the battery down, it makes for a swift replacement. **Left:** With no soldering keeping the battery down, it makes for a swift replacement.

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GADGETS

TECHY TOYS THAT MAY OR MAY NOT INSPIRE JOY

$TBC | ikea.com

Symfonisk Picture Frame WiFi Speaker

"Looks like music. Sounds Like art."

Smart speakers are making it pretty commonplace to have speakers in every room and while some speakers are nice to look at, sometimes you wish that you could have good quality audio without actually needing to put bulky speakers in every corner. Thanks to a collaboration between multi-room audio veteran Sonos and everyone's favourite Swedish furniture company, now your 'art' can now be the speaker in your room. Ikea's Symfonsik is available in the US in a range of different styles, with local availability on the way. The only way it could be better is if you could customise the artworks.

US$60 | otterbox.com

Otterbox Xbox Power Swap Controller Batteries

The closest thing to a permanently powered wireless controller.

There isn't much you could improve on the modern Xbox controllers, but it would be nice if the batteries could last forever. While this isn't exactly that, the Otterbox Xbox Power Swap Controller Batteries are functionally about as similar as you're going to get. By having two batteries for your controller you never have to suffer sitting a meter from your television to rejuice your controller again. Simply swap one for the other in the charging dock and you can play remotely for up to 10 hours before swapping over again.

$849 | antstream.com

Atari VCS

For when simply emulating retro classics isn't enough.

Here's another of the retro console remakes we've seen lately, like the Sega Megadrive Mini – but the Atari VCS ups the premium on all fronts. The box has a AMD Raven Ridge 2 APU and Ryzen GPU, and 32GB of storage for starters, and it's intended for use with the Antstream online library of retro games, which will include new and previously unreleased PC games. Or, you can play the games on your PC or TV via Nvidia Shield; there's no cost for that, it's an ad-supported service. Antstream is also building an esports community for retro gaming, so this full-fat retro service is more than just an emulator experience.

$TBC | copterpack.com.au

Copterpack

This carbon fibre drone backpack is taking off.

There have been a few working examples of mankind's fabled jetpack over the last few years, but we'll never turn down an opportunity to cover gadgets that let us bipedal-pigs fly. Details on the CopterPack are pretty thin on the ground, so other than a YouTube video of the big drone actually lifting a human over Palm Beach in Sydney, we can't really report on details like when this Aussie invention will hit shelves or how many multiples of your annual income it will cost. What we can say is that its dual rotor system is pretty amazing at pivoting and maneuvering.

US$79 | kck.st/2RJxnfs

Arrowmax SES Pro smart screwdriver

How did we make it this far without an automatic tech screwdriver?

Computer screws are often so tiny that you forget how much manual labor is involved in screwing tens of them in using only your fingers. Fortunately, there's a pretty neat Kickstarter for an automatic screwdriver designed specifically for tech sized screws. Seeing as it had amassed 30 times its funding goal more than a month out, it appears we're not the only ones who'd turn for this screwdriver. The driver has five torque settings that can be toggled by slightly twisting the grip, allowing you to get the perfect balance of speed and precision for each screw. Up to two hours battery life and inbuilt LEDs, what more could you want?

US$199 | tidbyt.com

Tidbyt

A retro display for current information.

On paper a 64 by 32 pixel display sounds a little silly, especially when you realise that it's for a screen that's the size of a bookshelf speaker, but once you look at this lo-fi retro display, it's hard not to be intrigued by the style of the throwback graphics. The Tidbyt connects to an app on your smartphone to display things like the weather, stock prices, your calendar and upcoming train timing in a simplified and stylish way. If you've got any basic Python skills you can even create your own Tidbyt visuals for whatever you want. ■

AUSTRALIAN PC AWARDS

The 2021 Australian PC Awards

Celebrating the very best in PCs and PC gear.

Each year, as we put together the Australian PC Awards, we carefully consider the products, technologies and the companies behind the gear from the year leading up to this. As hardcore tech fans, this is always a most excellent opportunity to pause and reflect on the events of the year passed – but this time we're looking at 2020, and we all know how impactful that year was.

There are many reasons why these particular awards are notable. They cover the period from the beginning of 2020 to March 30 this year (Covid affected our plans to do it in the usual tidy calendar year). In that time we not only saw generational leaps for almost every component – but the sheer importance of the PC came into a tighter focus than ever, as so many people shifted to working from home, thus placing critical importance on our PCs, and what we asked of them.

We worked on our PCs, and quite likely gamed on them at night to unwind and escape. We needed reliable high-performance machines that we could trust. And, through that period the PC delivered. Some PCs and some gear rose above the rest, though, and that's why we're here today – to acknowledge that which was simply better, and pleasingly in many cases, gear that raised the bar well above what we had any right to reasonably expect.

The teams from *APC*, *TechLife*, *TechRadar* and many of our Future Publishing editorial colleagues considered every corner of the PC, and we think we've picked the most worthy winners. In an exciting change of format we have also filmed a special video presentation! So head to the site on the left and catch us as we award the very best in the world of the PC.

Watch the complete Australian PC Awards video event, hosted by the team from *TechLife* and *APC* at www.australianpcawards.com.au

MOTHERBOARDS - BROUGHT TO YOU BY tom's HARDWARE

ASUS

BEST MOTHERBOARD MAKER

FINALISTS Asus, Gigabyte, Asrock, MSI

WINNER Asus

Motherboards from Asus consistently deliver great BIOSes and good physical layouts, albeit not as competitive at the value end of the market in this latest generation.

Asus motherboards have proven to their owners time and time again that they are both reliable and capable of the highest performance. They also often lead the industry with innovative features. We like the clear family split across budget to high-performance products that gives good choice without being overly complicated, and Asus offers well above average customer service.

BEST VALUE MOTHERBOARD

FINALISTS MSI MAG Z490 Tomahawk, Asus TUF B550M Wi-Fi, Asrock A520M-ITX/AC, MSI B550 Tomahawk

WINNER Asrock A520M-ITX/AC

The perfect partner for one of AMD's lower-priced CPUs (or APUs), this $150 board offers a great featureset for the price and even has AC Wi-Fi.

HIGHLY COMMENDED MSI MAG Z490 Tomahawk

A great choice for a user looking to build a powerful system without spending the big bucks.

BEST PREMIUM MOTHERBOARD

FINALISTS Asus ROG Zenith II Extreme Alpha, Gigabyte Z590 Vision G, Gigabyte Z590 Aorus Master, MSI MEG Z490 Ace, Asus Crosshair VIII Dark Hero X570

WINNER Gigabyte Z590 Aorus Master

Mega VRM and huge heatsinks that give lots of surface area for outstanding cooling, great quality components and even 10G LAN, which is unheard of at this pricepoint.

HIGHLY COMMENDED Asus Crosshair VIII Dark Hero X570

The best AM4 motherboard we've yet tested, we're so enamoured with it that it's become our AMD testbed. Fantastic memory support, supporting a very wide range of frequencies.

GRAPHICS CARD - BROUGHT TO YOU BY PC GAMER

BEST GRAPHICS CARD MAKER

FINALISTS MSI, Nvidia, Gigabyte Aorus, Inno3D, Sapphire, Asus

WINNER MSI

Consistently first-rate coolers from top to bottom of the range, enabling high performance and safe operation, and often priced cheaper than other brands.

HIGHLY COMMENDED Nvidia

30-series Founders Edition cards feature genuine engineering innovation with a unique cooling solution not seen before, and is superbly built.

BEST VALUE GRAPHICS CARD

FINALISTS MSI RTX 3060 Ti Gaming X Trio, PowerColor 6700 XT Hellhound, Gigabyte 3060 Vision OC, Inno3D 3060 Ti iCHILL X3, Gigabyte 3060 Ti Vision OC

WINNER MSI RTX 3060 Ti Gaming X Trio

A mid range card with a flagship design.

HIGHLY COMMENDED Gigabyte 3060 Vision OC

Ideal for gaming or creating.

PowerColor RX 6700 XT Hellhound

Great value, excellent cooling.

BEST PREMIUM GRAPHICS CARD

FINALISTS Nvidia 3080 FE, Asus ROG-Strix-RTX3080-O10G-Gaming, MSI GeForce RTX 3080 Suprim, AMD Radeon 6800XT, Sapphire RX 6800 XT Nitro+

WINNER Asus ROG Strix RTX3080 O10G Gaming

A quiet, cool, powerful and feature loaded card. It's got the lot.

HIGHLY COMMENDED MSI GeForce RTX 3080 Suprim

A powerhouse of high clocks and quality cooling to tame it.

CPU - BROUGHT TO YOU BY apc

BEST VALUE CPU

FINALISTS Intel Core i5-11400F, Intel Core i5-10600K, AMD Ryzen 3 3300X, Intel Core i5-10400F, Intel Core i3 10105F

WINNER Intel Core i5-11400F

With impressive performance for less than half the price of a 5600X, for those on a budget, this is a slam dunk.

HIGHLY COMMENDED AMD Ryzen 3 3300X

It's a special little gem if you can get your hands on one.

Intel Core i5-10600K

This CPU offers the performance of a flagship CPU from just a couple of years ago.

STORAGE - BROUGHT TO YOU BY techradar.

BEST INTERNAL STORAGE MAKER

FINALISTS WD, Samsung, Adata, Crucial by Micron

WINNER Samsung

An unblemished record of quality, value and choice. Samsung is the first choice of many looking for great internal storage.

HIGHLY COMMENDED Adata

A smaller brand gunning to take on the premium makers, and delivering across its range.

BEST EXTERNAL STORAGE MAKER

FINALISTS WD, SanDisk, Crucial by Micron, Samsung, Adata, Seagate

WINNER WD

Thoughtfully engineered storage products covering every conceivable need.

HIGHLY COMMENDED Seagate

Innovative products like the Firecuda Gaming Dock demonstrate Seagate's commitment to innovation.

BEST SOHO OR HOME NAS

FINALISTS Synology DS1621+, Synology DS920+, Terramaster F5-221 NAS, QNAP TS-130 NAS

WINNER Synology DS1621+

A great combination of performance, capacity, features, expandability and price point for any SMB.

HIGHLY COMMENDED Synology DS920+

Simultaneously a great expandable entry point for NAS newbies and a powerful, feature-laden office server for SMBs.

BEST PREMIUM CPU

FINALISTS Intel Core i9-10850K, Intel Core i5-11600K, AMD Ryzen 7 5800X, AMD Ryzen 9 5950X, AMD Ryzen 5 5600X

WINNER AMD Ryzen 7 5800X

A great enthusiast processor, Intel can't beat it, does everything well without breaking the bank.

HIGHLY COMMENDED AMD Ryzen 5 5600X

For a gaming-only focus the 5600X is perfect.

Intel Core i5-11600K

Very competitive performance at this price point.

SYSTEMS - SPONSORED BY eset

BEST VALUE LAPTOP OR 2-IN-1

FINALISTS Asus Zephyrus G14, Asus ZenBook 14, Asus ViVoBook S15, MSI Summit E14, Apple MacBook Air (M1), Asus TUF A15, Lenovo IdeaPad Flex 5

WINNER Apple MacBook Air 13-inch M1

The biggest laptop innovation we've ever seen.

HIGHLY COMMENDED Asus TUF A15 (2021)

Performance, price and perks.

Lenovo IdeaPad Flex 5 Chromebook

A great cheap alternative.

BEST PREMIUM LAPTOP OR 2-IN-1

FINALISTS Asus ZenBook Duo 14, Asus ZenBook Flip 13 OLED, Gigabyte Aero 15 OLED, Razer Blade Pro 17, Aftershock Vapor 17X, MSI Creator 15 A10UGT, Apple MacBook Pro (M1), Dell XPS 13 (9310), MSI Prestige 14 Evo A11M

WINNER Apple MacBook Pro M1

Incredible performance, double the battery and cheaper.

HIGHLY COMMENDED MSI Prestige 14 Evo A11M

Great all-round professional.

Asus ZenBook Duo 14 (UX482)

A unique premium product.

BEST GAMING LAPTOP

FINALISTS Asus ROG Zephyrus Duo 15, Asus ROG Zephyrus G14, Gigabyte Aorus 15P, Aorus 17G XC, Aftershock Vapor 15X, Aftershock Vapor 17X, MSI GL75 Leopard 10SFSK, MSI GE76-Raider

WINNER Asus ROG Zephyrus G14

A perfectly executed AMD package by Asus.

HIGHLY COMMENDED Aorus 17G XC

A powerful gaming weapon.

Alienware m15 R3

Seriously well engineered.

BEST DESKTOP PC MAKER

FINALISTS Thermaltake, Aftershock, MSI, PC Case Gear, JW Computers, PLE, Mwave

WINNER Aftershock

Insane personalised builds, at a price premium but you get a custom-built Ferrari for it. They also have the quality sewn up.

HIGHLY COMMENDED PC Case Gear

Well balanced and value builds, PCCG is always on the ball.

MSI

MSI often pushes the boundaries of PC design.

PERIPHERALS & COMPONENTS - SPONSORED BY ATEN

BEST MEMORY MAKER

FINALISTS Thermaltake, Adata, Crucial by Micron, Corsair, G.Skill, HyperX, Team Group

WINNER Team Group

Team Group's second Australian PC Awards win in this category, once again for remarkable and consistent value and a competitive range.

HIGHLY COMMENDED G.Skill

A range to please both enthusiasts and value-seekers, with unique aesthetics and usually offering very good value.

BEST COOLING PRODUCT

FINALISTS Asus ROG Ryujin 360, Corsair iCUE H100i Elite Capellix Liquid CPU Cooler, Thermaltake Toughfan 12 PWM High Static Pressure Radiator Fan, Be Quiet Pure Rock 2, Noctua NH-D15S Chromax

WINNER Corsair iCUE H100i Elite Capellix 240mm ARGB AIO CPU Cooler

A cooler that hits just the right balance of performance, low noise levels and value.

HIGHLY COMMENDED Noctua NH-D15S Chromax

If you're after a high performance air cooler, look no further.

Be Quiet Pure Rock 2

A great step up from bundled coolers that offers excellent value.

BEST MONITOR

FINALISTS Asus ROG Strix XG27UQ, Gigabyte M27Q Gaming monitor, Samsung Odyssey G9, Samsung Odyssey G5, Samsung Smart Monitor M7, MSI Optix MAG272C 165Hz Gaming Monitor, Alienware AW3821DW, Gigabyte G27F, LG CX OLED48

WINNER Alienware AW3821DW

A gaming screen that also really delivers for productivity, and is very good value.

HIGHLY COMMENDED Gigabyte G27F

Amazing value for a 27-in 144Hz IPS screen that does it all.

LG CX OLED48

For a TV - this is an incredible gaming monitor.

BEST KEYBOARD

FINALISTS Asus ROG Strix Scope RX, Corsair K100 RGB Mechanical Gaming Keyboard, Thermaltake Argent K5 RGB Gaming Keyboard, Razer Huntsman V2 Analog, Ducky One 2 Pudding, Logitech G915 TKL

WINNER Razer Huntsman V2 Analog

A rare case of an expensive product delivering everything it promises and offering real value. Analog keys are game-changer – literally.

HIGHLY COMMENDED Logitech G915 TKL

Absolutely everything you could wish for in a wireless productivity keyboard.

Ducky One 2 Pudding

No fancy tricks, but it's just beautiful to look at and use.

BEST MOUSE

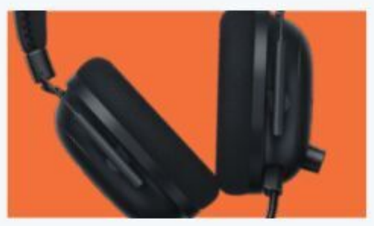
FINALISTS Asus ROG Chakram, Razer DeathAdder V2 Pro, Glorious Model O Wireless, Logitech G Pro X Superlight

WINNER Logitech G Pro X Superlight

Small, light, simple and ideal for gaming as well as regular use. A real delight to use.

HIGHLY COMMENDED Razer DeathAdder V2 Pro

An updated sensor and extremely durable switches make this a great mouse for dedicated gamers.



BEST GAMING HEADSET

FINALISTS Asus ROG Strix Go 2.4, Corsair HS75 XB Wireless Gaming Headset for Xbox Series X, Razer BlackShark V2 Pro, HyperX Cloud Alpha S, Audeze LCD-GX Gaming Headset

WINNER Razer BlackShark V2 Pro

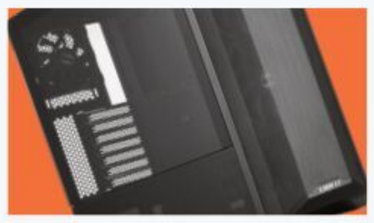
Brings in key gamer features like 2.4 wireless and THX Spatial Audio in a quality package with top notch sound quality.

HIGHLY COMMENDED HyperX Cloud Alpha S

Priced at the upper end of 'value' but with premium features.

Audeze LCD-GX Gaming Headset

Supreme planar-driver sound quality derived from audiophile cans.



BEST PC CASE

FINALISTS Corsair 5000D Tempered Glass Mid-Tower, Thermaltake The Tower 100 Mini Case, Thermaltake Divider 300 ARGB, Fractal Design Define 7, Lian Li Lancool II Mesh, Phanteks Eclipse P300A Mesh Edition

WINNER Lian Li Lancool II Mesh

Excellent air ventilation plus styling that's got universal appeal.

HIGHLY COMMENDED Thermaltake The Tower 100 Mini Case

A sleek, vertical, mini-ITX case with nice cable management.

Phanteks Eclipse P300A Mesh Edition

Under $80 yet with tempered glass, a PSU cavity and great styling.

BEST ROUTER

FINALISTS Asus ZenWiFi XT8, Asus ZenWiFi CT8, D-Link COVR-X1873 AX1800 Mesh Wi-Fi 6, Tenda MW12, Linksys Velop WiFi 6 AX4200, Netgear Nighthawk AX8

WINNER Netgear Nighthawk AX8

Enhanced security and top performance. It may be expensive, but the RAX80 is the Wi-Fi 6 router to get.

HIGHLY COMMENDED Tenda MW12

Fast, well-featured, easy-to-use with good, reliable coverage, and super-affordable – everything you could want from Wi-Fi.

RESELLER - SPONSORED BY SAMSUNG

BEST RESELLER

FINALISTS PLE, Mwave, Scorptec, Aftershock, Computer Alliance, Umart, PC Case Gear, JB Hi-Fi

WINNER PLE

PLE's excellent website allows easy editing of pre-built designs and their unique and wide range of cases is impressive.

HIGHLY COMMENDED Scorptec

A huge range of gear that covers everything you could want.

SPONSORED BY DELL

EXCELLENCE AWARD

For the person, product or technology that advanced the PC more than any other.

FINALISTS

Apple M1 processor, ultra-fast refresh rate monitors, Intel Iris Xe Graphics, AMD Ryzen 7 4800HS, AMD Zen 3 core, Nvidia DLSS 2.0

WINNER Apple M1 processor

The biggest WTF moment in computer processors for 20 years.

HIGHLY COMMENDED Intel Iris Xe Graphics Intel doubled integrated GPU performance for light 1080p gaming on Ultrabooks.

BROUGHT TO YOU BY GETPRICE

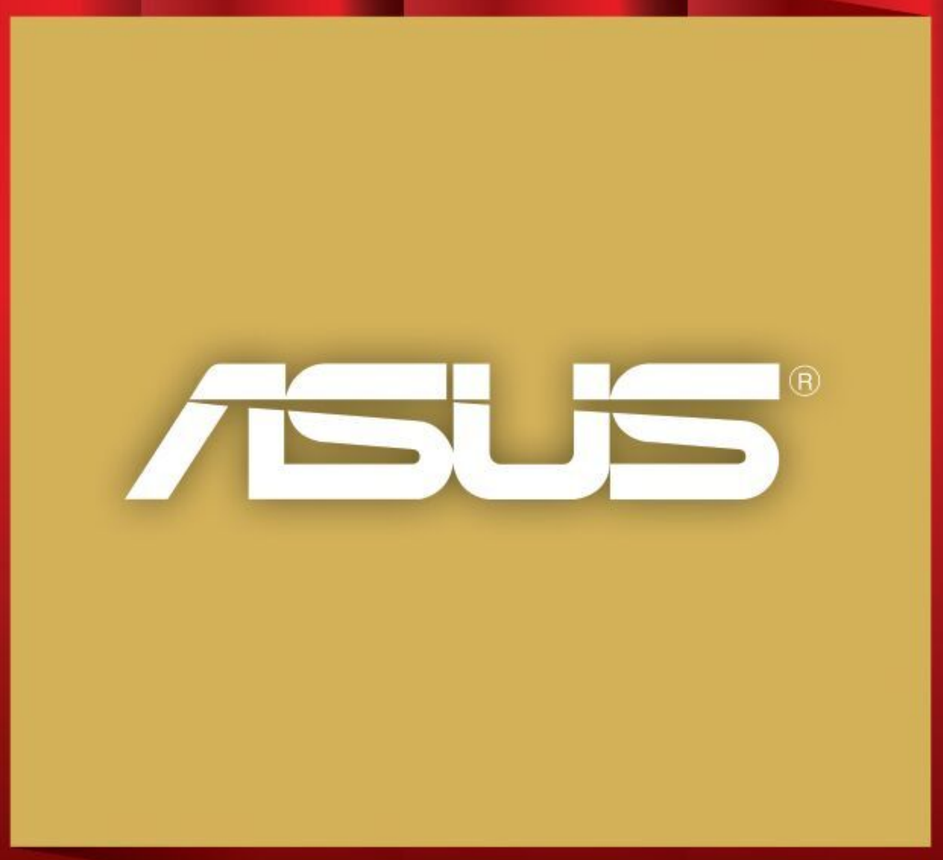
GOLD AWARD

The Gold Award is given to the company deemed to be the very best of 2020. To stand out in a field of such spirited competition, in the ever-evolving cauldron of PC tech, requires a team that has focus, talent, fresh thinking and the ability to deliver. Winning is the mark of a team that has it all.

Taking home the Gold is an honour its winner can be especially proud of – and that's because it is you that decided this one. Voting has been running across our sites and we hope you had your say!

WINNER ASUS

Asus is the company that does it all, and does it well. With a reputation for quality and reliability, great engineering and always pushing the industry forwards with clever new products and ideas, Asus covers a huge spectrum of product categories and is trusted and genuinely loved by its customers.



THE 2021 AUSTRALIAN PC AWARDS **ARE PROUDLY PRESENTED BY**

ATEN DELL ESET SAMSUNG

AND ALSO PARTNERED WITH

XPG | ADATA AFTERSHOCK YOUR RIG YOUR CHOICE ALIENWARE ASUS CORSAIR crucial by Micron

GIGABYTE msi PCCG RAZER SanDisk thermaltake WD

REVIEWS

THE HOTTEST GEAR LABS TESTED

apc HOT PRODUCT

$3,499 | gigabyte.com

Aorus 15P YD

Aorus is first past the post with Intel's 11th gen H series processors, but is this top shelf gaming laptop a real winner?

Gigabyte is good at being first in our review door when a new processor lands, but the 15P YD arrived alongside Intel's own (non-finalised) reference model, which is pretty amazing for a ready-to-buy gaming laptop. It means it'll be *APC*'s first laptop with one of Intel's 11th generation Core H-series processors. The 15P YD features an i7-11800H CPU, which will likely be the most commonly adopted processor among gaming laptops.

If we compare this new processor with 16GB of RAM to an Aorus 15P we tested in March, with an i7-10870H and 32GB of RAM, you'll see raw performance gains of between 12 and 15 percent, a number we've become pretty used to seeing in generational updates. This puts it pretty much perfectly on par with AMD's Ryzen 7 5800H in processing power and general computing tasks.

While it hasn't really changed the gaming equation much – in fact, you could probably argue it's gone backwards thanks to lower peak boost clock speeds – it's a step forward for productivity uses, and will churn through the most demanding workloads.

The other standout features on the Aorus 15P YD are a surprisingly fast SSD and the returning 99Wh battery (the largest you can check-in on US flights). In sequential read and write tests the Samsung Gen 4 PCIe SSD managed 7,014MB/s and 5,093MB/s respectively. A figure we had to check since we've never seen storage run faster than about 5GB per second on a laptop. To put that in perspective, you'd be able to relocate your 70GB install of *Cyberpunk 2077* in around 10 to 15 seconds.

The Aorus 15P YD has a 15.6-inch Full HD IPS display that can be configured with a 360Hz panel, but we've only seen 240Hz options available locally. Either way these displays are professional E-sports level with minimal response times. The 15P YD also includes a Nvidia GeForce RTX 3080 GPU which gets close to 60fps running *Metro: Exodus* at 1080p Ultra with ray tracing and DLSS on, so you can expect 100fps plus on any Full HD first person shooters and 200+fps on less demanding online competitive games.

SPECS
W10 Home 64-bit; 15.6-inch 360Hz IPS display @ 1920x1080 pixel resolution; Intel Core i7-11800H CPU; Nvidia GeForce RTX 3080 GPU, 16GB RAM; 1TB Samsung Gen.4 PCIe SSD; 99Wh battery (4h 17min 1080p movie playback); 35.7x24.4x2.7cm; 2.2kg.

Despite having a giant battery, the device's lifespan wasn't overly large, lasting just 2 hours and 15 minutes under load and four hours and 17 minutes in 1080p movie playback. Gigabyte does feature an AI software that runs in the background and switches your PC into different states for performance or longevity benefits, but we had this disabled for our benchmarking. With this on you might be able to stretch battery life out a bit, but we wouldn't recommend going anywhere without the charger.

The keyboard is really nice to type on, but is much softer than anything going for a more mechanical feel and the unit includes Wi-Fi 6 and all the latest interface and networking options. At close to 3cm thick and 2.2kg it's definitely of gaming laptop proportions, but it's actually amazingly weighted considering it's running a RTX 3080 GPU. It also looks deceptively sleek in its uniform matte black metal chassis.

JOEL BURGESS

An impressive E-sports gaming laptop that lands at a fair price.

★★★★½

Best result
On test

	Aorus 15P YD	Aorus 15P XC
PCMark 10 - Overall (score)	7,258	6,169
Max CPU Temperature (C)	89	94
1080p movie playback (HH:MM)	04:07	04:35
HWBot x265 - 1080p (Ave fps)	56.609	49.084
3DMark Time Spy (score)	10,915	9,926
The Division 2 - 1080p Ultra (fps Av.)	97	87
CrystalDiskMark Read (MB/s)	7,014	3,267
CrystalDiskMark Write (MB/s)	5,093	2,543

HOT PRODUCT

$699 | www.asus.com/au

Asus ZenWiFi XD6

The mini version of our favourite router, at a much lower price. But, what's the performance hit?

Regular readers will know how we're big fans of the Wi-Fi industry's, two-node, 'mega-mesh' routers, which see one node plugged into your modem and the other placed at the far side of your premises. They connect via a dedicated, wireless backhaul channel which offers dramatically better performance than regular mesh systems. Asus practically invented the technology but it's since been emulated by (a farcically priced) Netgear and an under-performing TP-Link rival. So, what does the XD6 bring to the mix?

First is the slightly more refined design. The new, diminutive, white nodes have a lightly brushed exterior with a subtle, pearl lustre that wins the industry's catwalk competition. But, with a slightly smaller chassis than Asus' own XT8 sibling and a significantly smaller surface area than Netgear's (huge) Orbi rival, how does this affect performance?

Unlike these tri-band, AX6600 competitors, the XD6 offers dual-band, AX5400 (5,400MBps) speeds. We ran our usual tests of downloading large video files from a Synology DS1019+ NAS to a Dell XPS 15 OLED laptop, next to the router, on the first floor and on the second floor of a three-storey, Sydney townhouse. Up close it managed a transfer rate of 787.6Mbps, then 430Mbps and 350.2Mbps as we moved up the residence. These are top-tier numbers to the point where the XD6 is the best all-round Wi-Fi performer we've ever tested!

Setting up was farcically simple: you download the app, enter some basic information, place the second node near to the first and everything just works.

In terms of features, it's got all the important ones plus some new innovations. One of the latter is a use-anywhere VPN. When out an about, you can connect via the XD6 to act as a secure VPN without paying for a third-party service. However, you will need a dedicated IP address from your RSP to get it working – not a shared one that is commonly used to cut costs.

A major boon is the perpetual, Trend Micro-based, AiMesh network security: Netgear and TP-Link have taken to only offering free trials of this and expect you to pay a separate subscription. It offers numerous, easy-to-understand insights and security recommendations plus edge security and can identify infected devices on your network and instantly protect against further infection. The parental controls are excellent with fully customisable operation schedules for each family member (and each device) along with some pre-set content-blocking suggestions.

There are excellent network monitoring and performance optimisation tools. QoS tools are adjustable via a simple drag-and-drop prioritisation. Accessing additional firmware features via a web browser gives you even more information and control and provides access to tools like port forwarding and bridge modes.

At $699 it's dramatically cheaper than the launch price of its rivals yet offers more features and similar performance to both – this makes it an undisputed winner. The only caveat is that its older, less-refined, XT8 big brother, with an extra band for headroom, can now be found at the same price.
NICK ROSS

SPECS
Speed: AX 5,400Mbps | Connectivity: 2x (3x Gigabit LAN, 1x WAN, 1 x USB 3.0) | Features: Trend Micro Security and family controls, Alexa compatible, IFTTT.

Best performance, best features, best user experience, best looks and a very reasonable price make it the best router on the market.
★★★★★

$499 | www.netgear.com

Netgear AX1800 4G LTE WiFi Router

A new, next-gen, Netgear Nighthawk. We have great expectations!

Netgear's Nighthawk range has historically impressed us with its powerful performance in the upper mid-range tier of the Wi-Fi world. Now here's a new Wi-Fi 6 model and it's got built-in 4G connectivity to boot. Will this mid-range maestro be the mainstream product to buy?

No, is the answer.

The Nighthawk LAX20 goes for the wedge-shaped spaceship approach to design. It's not small, with its tapered front end widening to 29cm to form a not-inconsiderable derrière. This further extends to 37cm with the two antennae adding additional width like some ill-advised cowboy chaps on a ballgown at the Oscars. There are two sockets at the rear to add antennae for the 4G, but these aren't included. All of this would be forgivable if size equated to performance, but what's delivered is unforgivable.

The LAX20 is rated at dual-band, AX1800 speeds (600Mbps 2.4GHz, 1,200Mbps 5GHz band), which is at the budget end of the spectrum and not ideal for a mid-range model. We ran our regular tests that see us download large video files from a Synology DiskStation 1019+ NAS connected to the router on the ground floor of a three-storey Sydney townhouse, to a Wi-Fi 6-equipped Dell XPS 15 OLED laptop. We do this up close, one floor up and then two floors up. Up close it managed a pitiful transfer rate of just 213.3Mbps. This is in line with poor, budget, last-generation mesh systems. One floor up it scored just 91Mbps. This isn't the worst score but is back of the pack pace-wise. Two floors up it managed 50.5Mbps, which is mediocre. In its defence, as 4G-enabled routers go, it has the best performance at range, but the next best choice is the Tenda AC1200 4G+, which scored 392, 30 and 23Mbps respectively and costs less-than one-third as much. Hmmm.

Then there's the set-up. Downloading the Nighthawk app and going through the motions is typically straightforward. However, be sure to have your 4G SIM ready to go – along with network log-in details that might not have been provided – as you'll be prompted to set that up first. If you skip it to prioritise a wired connection you'll need to run through the entire setup process again when you add 4G. Once up and running, you're left with an app that does virtually nothing. You can monitor and pause connected devices, turn on a Guest network and… that's it. Edge security by Bitdefender is offered but you only get a one-month, trial subscription. Basic web-browser-based settings succeed in little more than bamboozling you with jargon. The advanced settings include some USB storage settings, weird QoS controls, ham-fisted access scheduling and some basic port forwarding controls.

Connectivity includes the usual four Gigabit LAN ports, Gigabit WAN and a USB 2.0 port. The nanoSIM slot is a bit fiddly and we almost lost the card inside the devices body.

At $499 it's a positioned in the upper mid-range but its performance and feature-set are bottom-end budget. There are better choices to be found everywhere, frankly. Avoid.

NICK ROSS

SPECS
Speed: AX 1,800Mbps | Connectivity: 4x Gigabit LAN, 1x WAN, 1 x USB 2.0 | 4G LTE nanoSIM slot | Features: Network monitoring.

Overpriced, oversized, underpowered and underfeatured.

★☆☆☆☆

$1,299 | acer.com

Acer Predator X25

The latest speed demon in Acer's gaming monitor range was designed to help you kill latency.

Acer's got a new range of Predator monitors that cater to a few different gaming preferences, but if you've got a need for speed the 24.5-inch, Full HD Predator X25 is going to be your beast of choice. To put it bluntly, unless you're a pro gamer, or you're finding yourself often facing-off against Twitch streamers, then you really don't need a monitor with a 360Hz refresh rate. There are a heap of 144Hz and even some 240Hz monitors that go for less than half what it'll set you back for the full 360Hz. That said, if you're already at the top of your game and you're looking for that extra competitive edge, there's arguably no better way to do it than to get the fastest monitor you can.

The Predator X25 has a grey to grey response time of 1ms with some tests rendering in just 0.3ms, which means your screen is going to show you what's happening between five and 10 times faster than a cheap non-gaming display. The only other gaming tech likely to have this big an impact on competitiveness is your internet ping. Add to this the additional smoothness from over 300 frames a second and you'll have a major advantage on the movement and flow of the game.

In addition to speed, the Predator X25 has also been designed to feature precise colour accuracy. While it doesn't have an overly wide colour gamut the screen does feature a Delta E of less than 1, which means the colour variation between its pixels is small enough to be used for professional sRGB colour grading. While most pros will need a wider array of colours than full sRGB, this monitor is at least Vesa HDR400 so it'll go some way to looking more vibrant than your average gaming monitor, and it'll perfectly represent shadow and in-game brightness to ensure you're not missing anyone lurking in the darkness.

The screen includes Nvidia's new Reflex Latency Analyzer to allow you to test your overall system latency to see where your game is bottlenecking in its response time. Unfortunately there's a few hoops to jump through to use this tech. The most prominent is that you'll need to buy a new Reflex Latency-capable mouse. It's unfortunate that this tech doesn't just work with your gear off the shelf, but there were at least 21 compatible mice at the time of writing, and if you're forking out thousands for a new pro screen, it's not that much of a stretch to upgrade your mouse too. Without a paired mouse you'll pretty much only get access to 'Render Latency' (as long as you've got an Nvidia GPU), which you can display using the GeForce Experience on screen overlay, but with the right tools this software can break down mouse latency, PC lag and display latency so you can see your weakest link. To run it properly you'll pretty much need to have upgraded all your equipment already anyway, but it's a neat tool for serious gamers to ensure their equipment is up to scratch.

With a solid stand, ample interface options and an easy to navigate menu, the Predator X25 ticks all the boxes you'd want for a pro gaming screen.

JOEL BURGESS

SPECS
24.5-inch IPS LED display @ 1920 x 1080 pixel resolution; 360Hz refresh rate; G-Sync; ←1ms (GTG) response rate; 8-bit colour; Vesa HDR400; 400nit peak brightness; Nvidia Reflex Latency Analyzer; 1414.8 mm x 507 mm x 236 mm; 5.88kg.

A great pro-level Full HD gaming monitor with a few neat perks for a premium price.

★★★★☆

$799 (4TB), $409 (2TB), $219 (1TB), $199 (500GB) | crucial.com

Crucial X6 4TB SSD

Giving Samsung's T-series portable SSDs some serious competition.

With the X6, Crucial has delivered a solid external solid state drive for those looking for a suitably small storage device with an attractive price tag, Type-C connectivity and a larger-than-average capacity to boot. It is a no-frill portable SSD that has mass appeal but will leave those with a need for speed and wanting something faster, either based on USB 3.2 Gen 2 or Thunderbolt 3.

The X6 doesn't come with any software or a Type-A to Type-C cable – you are only provided with a Type-C to Type-C cable. Crucial quotes read speeds up to 540MBps via the USB 3.1 Gen-2 Type-C interface. Our benchmark tests show that the Crucial X6 hitting 464MB/s and 432MB/s on read/write speeds. A single 10GB file was transferred in less than 33 seconds, yielding a transfer rate of more than 300MB/s which was better than quite a few of the rivals we tested recently.

The X6 target price-sensitive users who are looking for a portable storage device that is faster or smaller or more resistant than an external 2.5-inch hard disk drive and you want something fast. If you plan to move large files around often, then the X6 might not be your best bet as its real life speed is poor compared with others out there given that it is stuck on USB 3.2 Gen 1 technology. The X8, the bigger brother of the X6, is twice as fast – thanks to USB 3.2 Gen 2.

DEISIRE ATHOW

Very small and light, with a good capacity and reasonable speeds.

★★★½☆

$179 | www.hyperxgaming.com

HyperX Alloy Origins 60 mechanical gaming keyboard

60%-sized keyboards are the new 100%.

Weighing in at 781.5g and built on an all aircraft-grade aluminium frame, the Alloy Origin is a hefty unit given its petite dimensions of 296mm(w) x 105.5mm(h) x 36.9mm(h). The exposed HyperX red switches and PTB keycaps float above the beautifully minimal unshrouded design and assist in casting rhythmic RGB lighting effects across the desk. It really is a beautiful keyboard. Around the back is the three-level angle adjustment and on the left hand front edge is a single, detachable USB-C port for the 1.8m braided cable. While there's no USB passthrough or dedicated media controls, the Alloy Origins 60 manages to pack in all the lesser used functionality of an extended keyboard via secondary key functions and the Function (FN) key. And that's also where the media and RGB lighting controls, home bank and F1-12 are all tucked. There was never a time throughout our review where we missed having primary access to these keys, however we could see potential irritation for gaming where there's demand for dedicated F keys depending how you like your set up.

But if gaming isn't your thing and you're just looking for something to mash out alphabets, the full-sized caps and traditional spacing are a delight.

Included in the package is a bonus ESC key and space bar with a fancy topo pattern. The Alloy Origins 60 is also compatible with PlayStation 4 and 5, as well as Xbox Series X/S and Xbox One. We would have loved a little carry bag for portability.

TROY COLEMAN

The Origins Alloy 60 packs bags of functionality into a stunning, minimal design.

★★★★★

apc HOT PRODUCT

$1,699 | www.gigabyte.com

Aorus FV43U gaming monitor

What makes a monitor a monitor and not a TV?

We recently reviewed the big, beautiful (and expensive) Asus ROG Swift PG32UQX and declared it the perfect monitor. Now, Gigabyte's Aorus gaming brand has said, 'Hold my beer' and delivered a colossal, 43-inch gaming monitor. But is it too big?

Sitting up close to this monster initially feels like you're a naughty two-year-old staring at the TV from way-too-close. For office work, especially, you'll need to be turning your head side to side and up and down to see from one end to the other. The 3,840 x 2,160 resolution is just sharp enough for clear office work, but only just. The lower-than-normal pixel density means you can see pixilation in lettering where you shouldn't, if you don't get your Windows zoom settings right. To be frank, this wasn't ideal for extended working as the regular head movement (which goes against OH&S advice) gets wearying. Nonetheless, there were times where spreading several, fully-open documents across a screen at once became a productivity boost.

Another gripe is port placement. The power lead plugs into the left while the computer cables plug into the right. They don't look very neat. Furthermore, unless you have long, high-quality computer cables that stretch all the way to the right-hand side of the screen, you won't be able to have your computer on the left.

All that aside, this being a gaming monitor means it lives and dies with its gaming performance. Quantum Dot-generated colours are bright and vibrant. A 144Hz refresh rate (with 1ms MPRT) keeps motion smooth in fast-and-frantic shooters and this is enhanced by VRR (Variable Refresh Rate) to stop graphical tearing. There's also ALLM (Auto Low Latency Mode), which tells the screen that a console is connected and requires a low-latency connection. Meanwhile banks of rear-lit LEDs can generate 1,000 nits of brightness (and some heat!) which makes HDR-enabled games look phenomenal – literally blinding if you're sitting too close when everything fully lights up. 10-bit colour helps ensure that colour gradients are smooth although we did notice some banding appear in monochrome gradients. It's a decent technical performer too: covering 97 per cent of the DCI-P3 colour gamut and each unit is factory-calibrated. Ultimately, gaming and multimedia content looks stunning… so long as you sit back from the screen.

SPECS
43-inch, matte, 3,840 x 2,160, flat-screen, 10-bit, VA, 144Hz LCD. 1ms MPRT response time. 1,000 nit brightness. 4,000:1 contrast. 97% DCI-P3 (factory calibrated). HDR10, VESA Display HDR1000. DisplayPort 1.4, 2 x HDMI 2.1, 2 x USB 3.0, USC-C, USB-B, 2x 3.5mm audio jack. 2 x 12W speaker. IR Remote. 967 x 586 x 251 mm, 15.3KG.

The built-in speakers are very impressive: they get very loud and provide good, all-round fidelity with punchy bass. Gaming features include black equaliser to reveal enemies hiding in shadows; on-screen crosshairs; Picture-in-Picture and intricate colour controls. There's even a KVM function that lets you connect a single keyboard and mouse to the monitor and have it act as an input hub for other devices (via USB-C).

The FV43U's existential question is, 'What makes this a monitor and not a TV?' It's a grey area. It's not particularly comfortable to use as a day-to-day, office-work monitor but it's better than a reflective TV. If your primary use-case it to sit (well) back and use it for high-quality gaming and multimedia with some office work then, at $1,699, it's a good buy.
NICK ROSS

An ungodly sized missing link between gaming monitors and TVs.
★★★★★

apc RECOMMENDS

Headset only: $1,299 (requires separate purchase of controllers and base stations) | vive.com/au/product/vive-pro2

HTC Vive Pro2

HTC's new challenger for best headset in the high end / professional PC VR segment.

The high-end PC VR market is currently a two horse race. The excellent Valve Index has the edge in tracking quality, controllers and 144Hz refresh rate. But it's falling behind with a 1,440 x 1,600 per-eye resolution. The equally excellent HP Reverb G2 is the leader on visual fidelity, with 2,160 x 2,160 pixels per-eye resolution delivering utterly amazing visuals. But its 90Hz refresh rate is starting to look a bit pedestrian and its inside-out tracking system can be a bit hit and miss.

With HTC's launch of the Vive Pro2 headset a third horse has entered the race, and it is gunning for top spot. On paper the Pro2 looks impressive, boasting a 5K (2,448 x 2,448 per-eye) resolution, 120Hz refresh rate and 120° horizontal FOV. So, do we have a new king of VR headsets? Let's find out.

Making good better

The Pro2 starts off strong with the use of Valve Lighthouse tracking. While setup is a bit more complex, it offers arguably the best tracking system in the VR market today. It also means you can replace the standard Vive controllers with Valve Knuckles, which you will want to do immediately. Not to say that the Vive controllers are bad (they are perfectly functional), but the Knuckles revolutionised VR controllers. If you are a serious VR enthusiast, the Knuckles are a must have. Being able to seamlessly integrate the Knuckles with the Pro2 is a big plus.

Ergonomics and comfort are also strong points. The headset is on the bigger and heavier side but is well balanced. Coupled with the soft padded headstrap, face cover and on-ear headphones, the Pro2 is seriously comfortable. It also offers excellent adjustability with 57-72mm IPD range and generous lens distance adjustment catering for use of glasses.

The Pro2's built in headphones offer good quality audio and are more than sufficient for general gaming. Audiophiles may find they lack a bit of depth and clarity, but this is easily solved as the headphones are removable, allowing you to use your own audio headset or external audio in VR. The Pro2's mic is best described as adequate. It works fine for general communication, but frequently distorts on plosive sounds. If you are streamer or record your play sessions, you will want to invest in a better alternative.

SPECS
Resolution: 2,448 × 2,448 pixels per eye (4,896 x 2,448 pixels combined); Refresh Rate: 90Hz or 120Hz; Panel Type: Dual RGB low persistence LCD; Audio: Hi Res certified headphones; Mic: Dual Integrated microphones; Tracking: Outside In, SteamVR 1.0 and 2.0; IPD: Manually adjustable 57mm to 72mm.

That leaves visuals, an area where we expect the Pro2 to shine, and for the most part it does. The Pro2's LCD panels are exceptionally good. Colours are vivid and bright, there is no sign of mura and they offer great contrast. Coupled with the 5K resolution and 120Hz refresh rate the Pro2 can deliver incredibly crisp, clear and buttery smooth visuals.

Unfortunately this goodness is let down somewhat by the Pro2's optics. The Pro2's fresnel lenses suffer from god-rays. While no worse than some other headsets (notably the Index), it is disappointing when compared to the G2 where this effect is almost non-existent.

The sweet spot is also small, with noticeable distortion towards display edges. As with most VR headsets this can however be improved by getting the lenses as close as possible to your eyes. I was already running the Pro2 with the lens distance adjustment at minimum, but the Pro2's standard face cover is pretty thick leaving some room for further improvement. As an

experiment I replaced it with a thinner aftermarket cover I had lying around. This resulted in a marked improvement in the visuals for me, and largely eliminated my struggles with the sweet spot.

The PC you'll need

On the hardware front, achieving a good experience surprisingly does not require unreasonable hardware. HTC lists a GTX 1060/RX 480 as the minimum requirement and testing with my causal gaming PC (i7-7700K/GTX 1080Ti) gave good results and visuals, albeit at lower resolutions. But getting the best out of the Pro2 will require the finest grade unobtanium hardware, with even my sim gaming PC (17-10700K/RTX 3090) unable to deliver 120fps at 5K in graphically demanding titles.

As part of testing I ran a range of VR titles, ranging from simpler experiences (*Superhot VR*, *Beat Saber*) to some popular VR games (*Skyrim VR*, *Star Wars Squadrons*, *Elite Dangerous*) through to simulation titles (*Assetto Corsa Competitione*, *DCS*).

On my 1080Ti system all the titles managed to run well and looked great, although for the more complex games I did have to drop down in-game graphics settings.

The 1080Ti could not run the Pro2 at full visuals though, with resolution capped at 1,881 x 1,836 per-eye at 90Hz refresh rate. This is due to bandwidth limitation on the DisplayPort connection. To run higher resolutions, you require a compression technology (Display Stream Compression or DSC) to fit all those pixels onto the connection. The 1080Ti does not support DSC and so when used with the Pro2 is capped at 1,881 x 1,836 @ 90Hz. It's worthwhile to confirm your graphics card supports DSC if you want to get the most out of the Pro2.

My RTX 3090 system (DSC compliant) did unlock the full glorious 2,448 x 2,448 at 120Hz experience. But while the simpler VR titles ran without missing a beat, the more complex simulation titles mostly proved too much for even the mighty 3090. In less demanding sequences I could manage periods of play at 120Hz. But as soon as things started getting busy the 3090 would drop to 60Hz.

This presents a bit of a dilemma for the Pro2. While it can deliver stunning visuals, until technologies like VRSS and DLSS get better traction, using the Pro2 will be a constant exercise in compromise – meaning either dropping the refresh rate to get better resolution, or dropping the resolution to get the 120Hz refresh rate. For me, the best compromise was keeping resolution at 2,448 x 2,448 but dropping to 90Hz, which with a bit of tweaking (well, actually quite a lot), I did get to run smoothly on all titles.

Conclusion

So has the Pro2 claimed the top spot? Not in my view. I do think it beats out the Index, but it is a dead heat between the Pro2 and the G2.

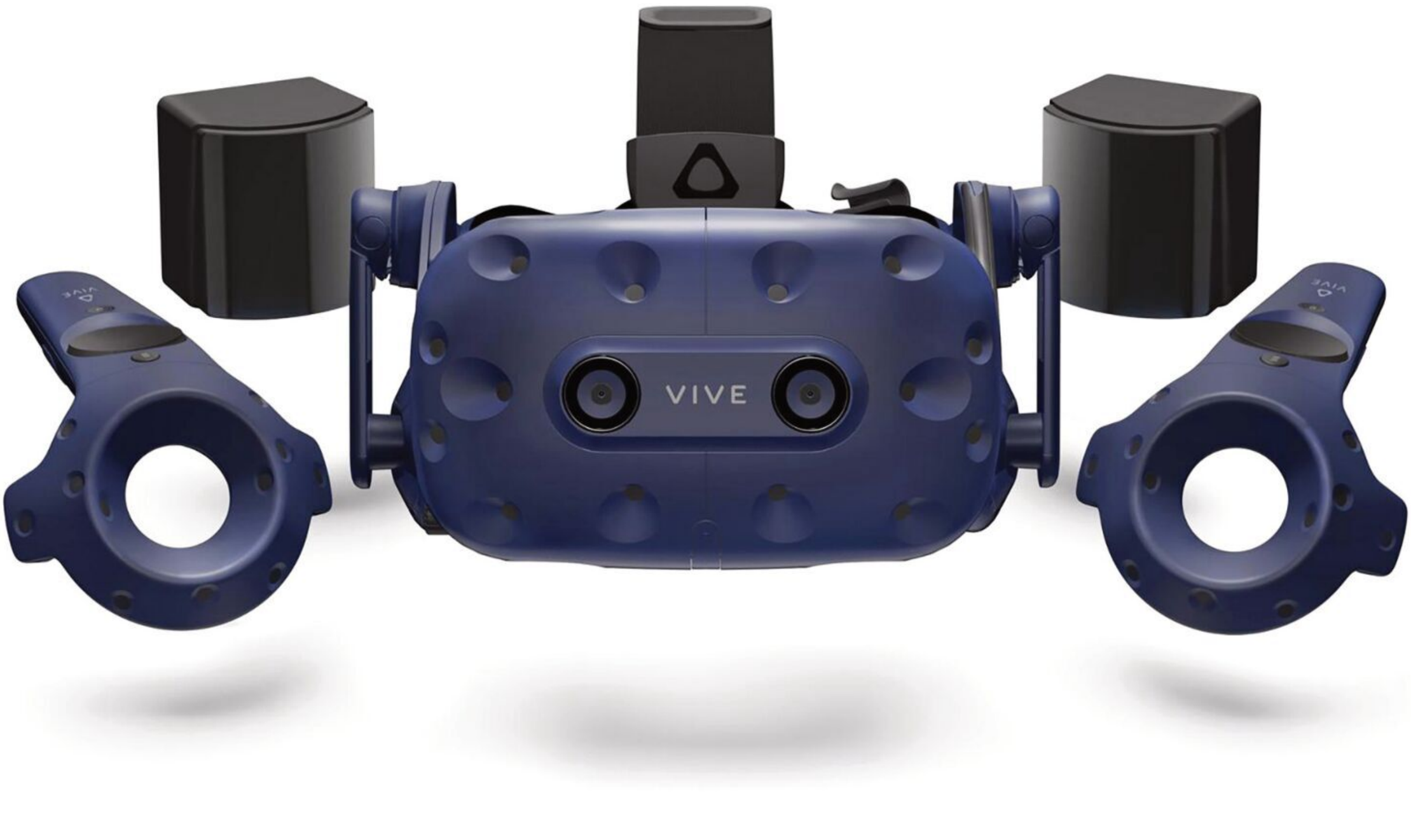
If tracking and controllers are important to you, money is not a consideration and you mostly play standing/moving VR games, then the Pro2 (coupled with Lighthouse sensors and Knuckles controllers) will give you the best VR experience.

If tracking is less important (e.g. you mostly play seated or simulation titles), you are irritated by visual irregularities (e.g. god-rays) and cost is a consideration, then the Reverb G2 is still hard to beat.

PETE VEEDUB

The Pro2 is an excellent PC VR headset, only held back from being the outright king of PC VR by average lenses suffering from god rays and a small sweet spot.

★★★★☆



The Vive Pro2 full kit. The controllers and base stations are sold separately.

LABS ROUNDUP

Nvidia GeForce RTX 3080 Ti & 3070 Ti

Ampere's mid-life refresh hits the shelves – in a manner of speaking.

As gamers ourselves, we love it when new graphics cards hit our labs. But as has been the case with launches over the past year, we have to begin with a lament about the sad state of the PC market. GPUs continue to sell at inflated prices and stocks continue to be scarce. It's a problem that's affecting the wider semiconductor market too, but when you add the double whammy of crypto mining demand, the result is ridiculous pricing at levels well above RRPs. But, there's hope! The RTX 3080 Ti and RTX 3070 Ti both introduce a hash rate limiter that reduces their appeal to miners. We really hope that this leads to more cards in the hands of gamers at reasonable prices. Anyway, enough about all that. Let's take a look at the RTX 3080 Ti and RTX 3070 Ti!

Under the hood

The RTX 3080 Ti makes use of the same GA102 GPU as the 3080, but with extra cores unlocked. There's also a wider memory bus that allows Nvidia to equip the card with 12GB of memory. In short, the 3080, 3080 Ti and 3090 contain 8,704, 10,240 and 10,496 cores respectively. Arguably the bigger changes are with regards to the memory subsystem. The 3080, 3080 Ti and 3090 have 10GB over 320-bit, 12GB over 384-bit and 24Gb over 384-bit respectively. As you can see, this places the 3080 Ti much closer to the 3090 in spec than it is to the 3080.

The RTX 3070 Ti makes use of the GA104 GPU, which is shared with the 3070 and 3060 Ti. The 3070 Ti uses the full capabilities of the chip, with all cores unlocked. The 6,144 cores of the 3070 Ti compares to the 5,888 of the 3070 and 4,864 of the 3060 Ti. The 3070 Ti's biggest upgrade is the switch to faster GDDR6X memory compared to the GDDR6 of the 3070. The shift from 15Gbps memory to 19Gbps gives the 3070 Ti bandwidth increase of over 30 percent. Regrettably, it's only got 8GB of memory. It's not a deal breaker by any means, but 1440p and 4K capable cards should ideally have more than 8GB in 2021. The competing RX 6800 has 16GB, and bigger numbers like that on the box do sell cards.

Of course, both of the new GPUs feature all of the tech that Nvidia's Ampere generation is known for, including its ray tracing capabilities and its ever more impressive DLSS 2.0 technology. This is an area AMD is yet to make an impact. Then there are desirable features such as the multimedia engine, Reflex low latency and Broadcast technologies. These all add value to users coming from older generation cards.

The 3070 Ti supposed to start at around $959 and the 3080 Ti at $1,999, but you can add a good wad of cash on top of that on the street. A glance at a price search engine at the time of writing shows basic 3070 Ti cards selling for well over $1,500. Add over a thousand on top of that for a 3080 Ti. That kind of money will get you a console, a good 4K TV and some games as well. Something's got to give. It won't always be like this, and when sanity prevails, at least we'll still have highly capable graphics cards! Let's take a look at a selection.

CHRIS SZEWCZYK

RRP $959 | www.nvidia.com

Nvidia GeForce RTX 3070 Ti Founders Edition

A solid offering with questions about its ongoing availability.

Though the top dog 3080 Ti gets most of the attention, the RTX 3070 Ti is arguably the more important release of the two. It's a lot more affordable and it's a compelling upgrade for users coming from older generation cards. Even with street prices that are grossly inflated, it offers 2080 Ti-beating performance at 2080 Ti-like prices. Can we interpret that as a small win in the current market?

The card itself is visually identical to the RTX 3070. For a card with a 290W TDP, it's very compact and its two-slot design will appeal to builders of compact systems. The cooler can be considered a hybrid of a blower and axial fan designs, and it's clear that Nvidia really put a lot of effort into it. There are triple DisplayPort 1.4a ports and a single HDMI 2.1 port.

Like all 3070 Ti cards, the Founders Edition uses the fully enabled GA104 GPU with 6,144 Cuda cores which run at a boost clock of 1,770 MHz, a slight increase from the 1,730MHz of the 3070 FE. The extra core and frequency bump helps, but the real benefit comes from the shift to faster GDDR6X memory, which runs at 19Gbps compared to the 14Gbps of the 3070. GDDRX is power hungry though, and it contributes to the 3070 Ti FE's 290W TDP which is a whopping 70W increase over the 3070 FE. It comes with Nvidia's proprietary 12-pin power connector. We're happy to see one connector vs the unsightly three of high-powered cards, but its mid card placement isn't ideal for clean build purists.

Despite its advertised 1,770MHz boost clock, our sample was happy running at 1,900MHz over a looping test. Its peak recorded temperature was 79c, which is about the maximum before you'll start to lose a little bit of boost clock. The cooler is audible but given its compact size, we have nothing but praise for Nvidia's FE coolers. The card recorded a peak gaming power consumption of 288w, which is over 60w more than we saw from the 3070 FE. That's a bit disappointing.

Given that we have GA104-based cards on the market, the 3070 Ti FE performed as we expected it to. It draws alongside the RX 6800 but it remains some way off of the RTX 3080. The FE was surprisingly close to the more expensive MSI but it was equally surprisingly some way off the monstrous Aorus Master. It can handle modern 4K games but it's probably best suited to a user of a high refresh rate 1080p or 1440p monitor. It's 8GB frame buffer is enough for now, but will it be in the future? Time will tell.

The simple cooler makes heat and noise creep up a little higher than most partner cards.

The 3070 Ti Founders Edition is an attractive offering in some ways, particularly if your games can make use of the increasingly impressive DLSS technology, but at the same time it doesn't really standout. Both the relatively minor performance gain tied to a major TDP bump over the non-Ti 3070 means that 3070 remains the better buy to us. Then there's the very competitive AMD RX 6800, which has twice the memory. In a normal market the 3070 Ti FE could be a compelling option. But, with availability an ongoing concern, it's not a great buy right now.

SPECIFICATIONS
Nvidia GeForce RTX 3070 Ti Founders Edition; 6,144 Cuda Cores; 1,770 MHz Boost Clock; 8GB GDDR6X 19 Gbps memory, 608 GB/s Memory Bandwidth; 3x Display Port 1.4a, 1x HDMI 2.1; 1x 12-Pin Power Connector; 290W TDP.

The steep rise in power consumption for not much of a performance gain leaves us a bit lukewarm on the 3070 Ti.
★★★½☆

apc RECOMMENDS

RRP $1,999 | www.gigabyte.com

Gigabyte Aorus GeForce RTX 3070 Ti Master

The top performing 3070 Ti in this test.

The Aorus Master 3070 Ti is a *big* card. This four-slot card is big, bright, beefy and brawny. If you want a GPU that draws attention to itself as much as what it shows on your monitor, then this is a card for you. As if you had any doubt after a glance, it's Gigabyte's flagship 3070 Ti. It comes with a 1,875MHz boost clock, a very nice 105MHz increase over the FE. It's got a bigger cooler, more power and more features. If you're looking for the best 3070 Ti you can get your hands on, the Aorus Master is going to be tough to beat.

The Aorus Master has several characteristics that set it apart from a basic 3070 Ti. This first is no less than six display outputs. These are 3x DP 1.4a, two HDMI 2.1 and a single HDMI 2.0 port. You can use any four at once. Then there's the side LCD which can display real time monitoring info or custom text and GIFs. The 3070 Ti Master is one of few GPUs to come with a four-year warranty. Just don't tell the miners that last part. You also get a 6-pin and two 8-pin power connectors, dual BIOS and as you'd expect, lashings of RGB lighting.

The Aorus Master's monstrous cooler packs in a lot of surface area and you'd expect it to laugh off the demands of the GA104 GPU. Gigabyte appears to have tuned the cooler for maximum performance as during a stress test, the cooler reached 70 percent fan speed. This means the card is louder than the likes of an Asus Strix or MSI Gaming X, but the advantage is its thermal performance, with a recorded peak of just 68c. That's a great result for a 300W+ GPU. The low temperature meant the card was able to boost to a consistent average of 1,980MHz. That's the highest clock we've seen on the fifteen or so RTX 30 series cards we've tested to date. While it can be heard, the noise is more like the sound of moving air rather than the whirring of fans. You can always adjust the fan curve if you prefer lower noise levels at the expense of a few MHz of boost clock. We're also a little unsure of the design of the cooler shroud, which may have the effect of trapping hot air inside the cooler. Is this the reason for the unusually high fan speed?

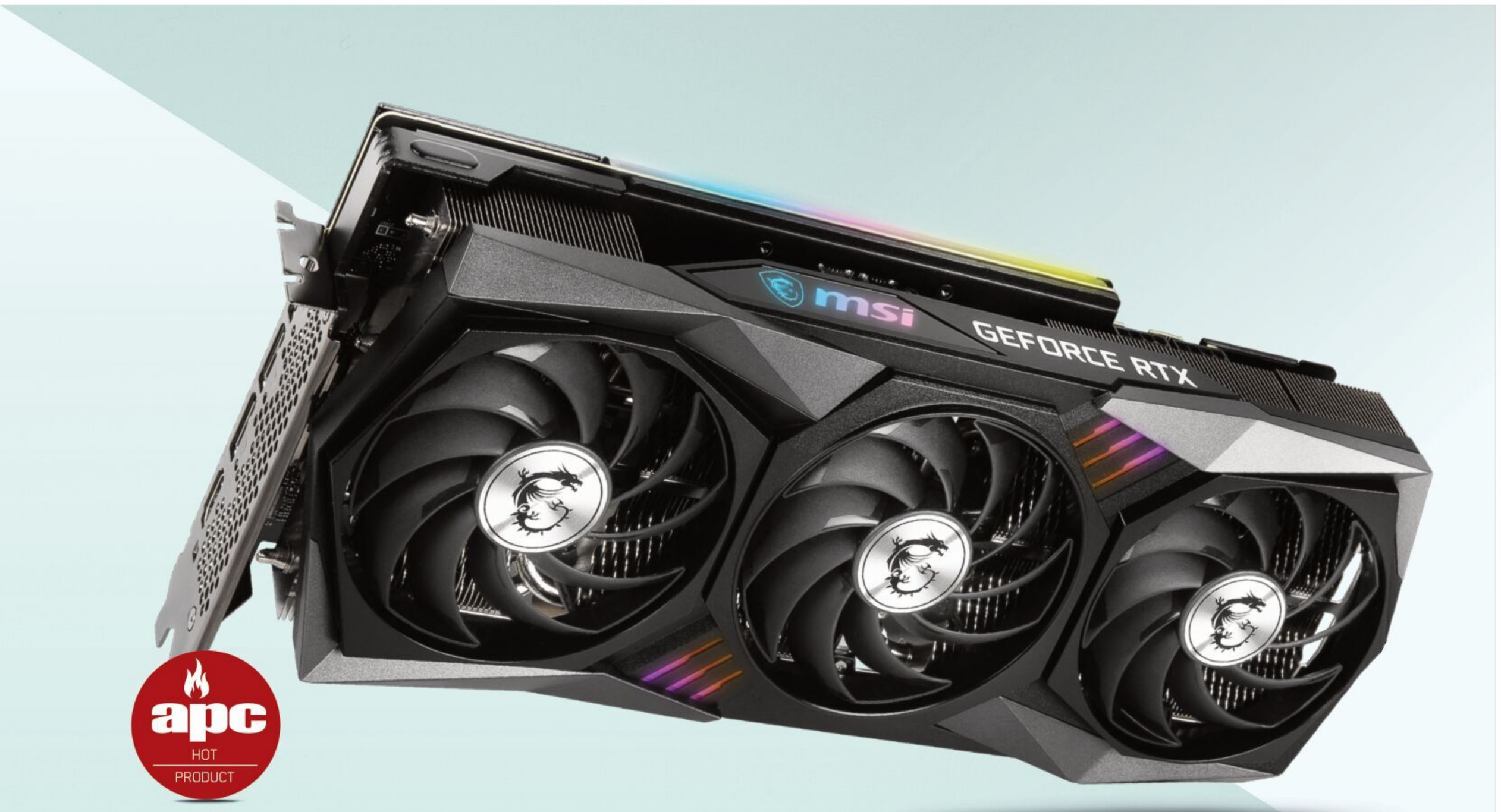
SPECIFICATIONS
Gigabyte Aorus GeForce RTX 3070 Ti Master 8G; 6144 Cuda Cores; 1,875MHz Boost Clock; 12GB GDDR6X 19Gbps memory, 608GB/s Memory Bandwidth; 3x Display Port 1.4a, 2x HDMI 2.1, 1x HDMI 2.0; 2x 8-Pin + 1x 6-pin Power Connectors 290W TDP.

The Master was consistently the fastest of the three 3070 Ti's across our benchmark suite. It consistently ran 80MHz higher than the FE card, and an impressive 65MHz more than the MSI Gaming X.

The Aorus Master is a great example of a flagship GPU but is it worth the extra money on top of already inflated 3070 Ti pricing? Compared to a $3,000+ 3080 or 3080 Ti, maybe it can! About the only criticism we have is with regards to its cooler. It performs very well but for some reason it seems to have to work harder than it should. It can't match the MSI in terms of noise levels. Having said that, the Aorus Master is a card that we'd be proud to own. If your PC is a piece of art as much as it is a bunch of electronics, then you must check out the Aorus Master.

If performance without compromise is at the top of your wish list, this is the 3070 Ti for you.

★★★★☆



apc HOT PRODUCT

RRP $1,899 | www.msi.com

MSI GeForce RTX 3070 Ti Gaming X Trio

One for fans of silent gaming.

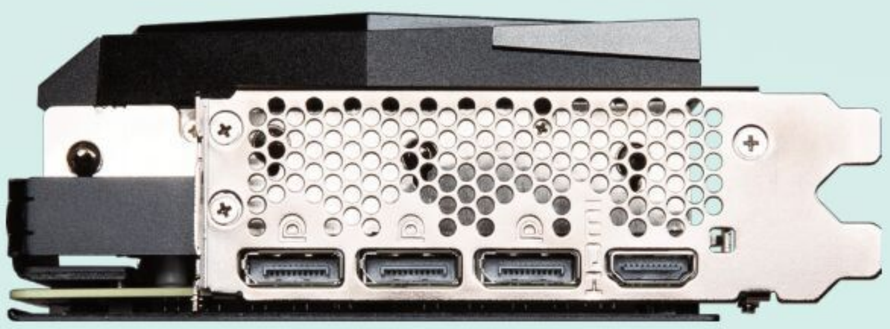
MSI's Gaming range used to be the flagship cards in MSI's range, but that honour now goes to the Suprim series. The Gaming X still comes with the excellent TriFrozr cooler, but since it eschews some of the bells and whistles of the likes of the Suprim or the Aorus Master, the Gaming X offers good value for money (in the current market – that's relative!) while keeping all the traits that have made MSI's Gaming cards consistently highly regarded.

The Gaming X is equipped with dual eight pin power connectors, which added to the 75W available from the PCIe slot, means the Gaming X is supplied with 375W of power supply capability. It features a 60MHz factory overclock with a rated boost clock of 1,830MHz, though as we'll see it can run much higher than this. Display outputs consist of a single HDMI 2.1 port along with three DisplayPort v1.4a ports.

The MSI is certainly a very large card. It takes up three slots. We note that MSI has chosen a more discrete design than we're seeing from some other companies. The cooling shroud and backplate blend grey and black with just a couple of subtle RGB sections joining the MSI logo on the side.

The highlight of the MSI Gaming X Trio is the large and highly capable TriFrozr cooler. It's capable of cooling the more demanding 3080 and 3090 class cards so straight away we know that the smaller GA104 GPU of the 3070 Ti won't be a problem. We saw a load temperature of just 69c. That's a few degrees warmer than the Aorus Master, but the MSI operates in all but complete silence, as opposed to the louder Aorus. The card held an average clock of 1,915MHz over 10 minutes of load. That's quite a bit less than the Aorus, but a bit better than the FE. If you're looking for maximum performance you might want to look elsewhere, but if you're looking for something that's quiet, the MSI is the pick of 3070 Tis, and our ears appreciate a quiet card just as much as outright performance.

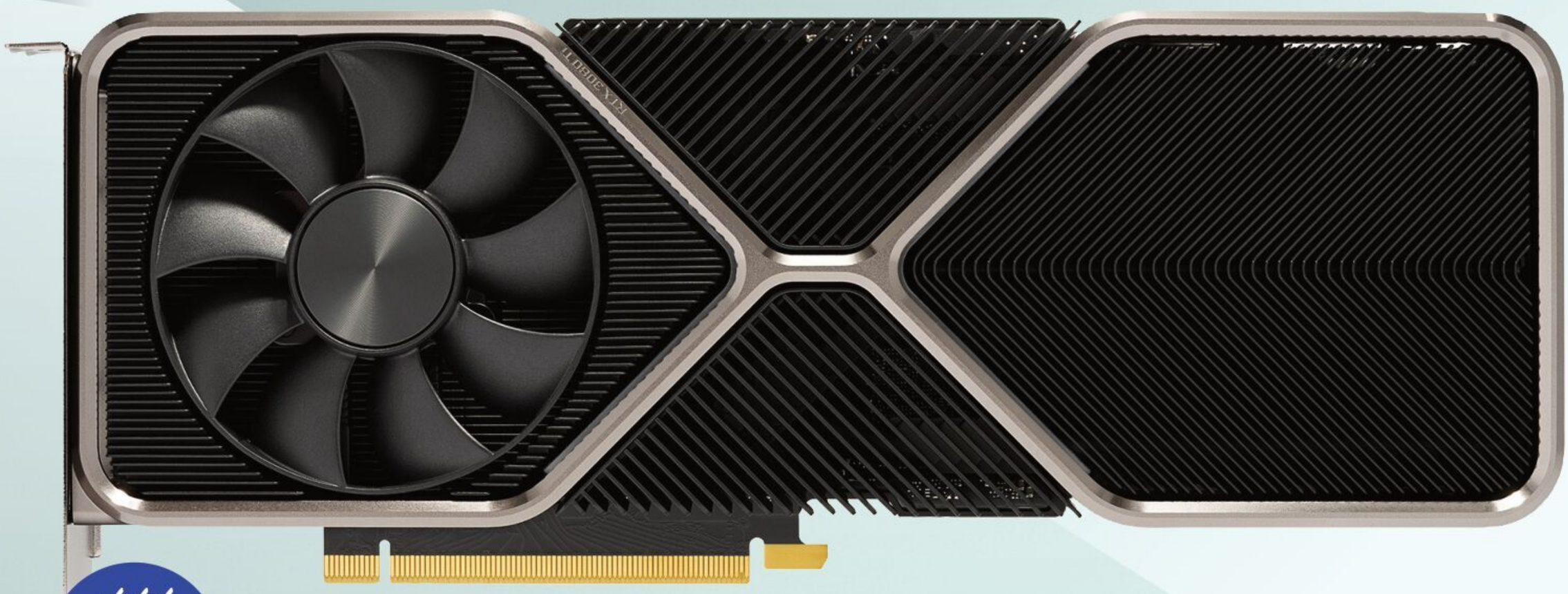
The MSI, despite its rated boost clock being 60MHz higher than the FE, didn't really outperform it by a significant margin, and ended up a few percent behind the more expensive Aorus. This probably illustrates how MSI is positioning the Gaming X as a good allrounder with emphasis on cooling and low noise levels compared to the flagship Suprim. The MSI certainly has a bit of headroom if you wish to increase the power limits and fan speeds for maximum performance.



SPECIFICATIONS
MSI GeForce RTX 3070 Ti Gaming X Trio 8G; 6,144 Cuda Cores; 1,830MHz Boost Clock; 12GB GDDR6X 19Gbps memory, 608GB/s Memory Bandwidth; 3x Display Port 1.4a, 1x HDMI 2.1; 2x 8-Pin Power Connectors; 310W TDP.

All of the 3070 Ti cards tested here are different. The Founders Edition is a quality offering that's well-suited to small form factor builds, the Aorus Master is the performance choice with all the extras, while the MSI is the card of choice for users looking for a well-built but effectively silent card. Which one you go for will depend on your personal criteria. As fans of silent computing, we're happy to recommend the MSI Gaming X. The company rarely makes a misstep and the 3070 Ti Gaming X Trio is another quality offering from MSI. We just hope that all 3070 Ti cards come down to more sane pricing levels in the months ahead.

The MSI Gaming X strikes the perfect balance of relative affordability and low noise levels.
★★★★½



RRP $1,920 | www.nvidia.com

Nvidia GeForce RTX 3080 Ti Founders Edition

Not your basic reference card anymore.

Founders Edition cards can't be considered your basic reference card any longer. Nvidia has really put a lot of effort into FE cards and it shows with its unique heatsink and fan design. We can mostly ignore the semi-professional Titan-like 3090. The 3080 Ti FE is Nvidia's gaming flagship and its purpose is to answer to the threat posed by AMD's 6900 XTXH variants. Should you consider a Founders Edition?

One of the major benefits of the 3080 Ti FE is its size. The card takes up only two slots and its height doesn't protrude much above the PCIe bracket. This keeps it widely compatible with a lot of cases. It comes with the standard three DP 1.4a ports and a single HDMI 2.1 port. It also comes with the proprietary 12-pin power connector that can provide up to 300w. We're still not fans of its placement as it doesn't help the cable management aficionados out there. But, given that many cards come with three 8-pin connectors, anything that helps to eliminate cable spaghetti is a step in the right direction.

The cooler is truly unique and it doesn't lose all that much in performance compared to many of the larger coolers you'll find on partner cards. A vapour chamber and four heatpipes channel heat away to the fans which are mounted on each side of the card One of them directs air into the front to back airflow that's standard in most cases. Nvidia really does deserve credit for elevating the standard of so called 'reference' cards.

A 15-phase PCB with 70a stages is easily capable of extracting the most out of the power hungry GA102 GPU without compromise. The TDP of the card remains at the same 350W of the non-Ti 3080 FE, though, To keep this TDP, Nvidia is forced to lower the boost clock of the 3080 Ti to 1,665MHz, down from the 1,710MHz of the 3080.

Performance wise, the card will trail most of the top tier cards, such as the Aorus Extreme, but it's surprisingly competitive with the Zotac Holo and Asus TUF. It was able to hold a stable boost clock of 1,830MHz. With DLSS enabled, you really can game at 4K with all ray tracing options turned on. And that's a sight to behold.

We saw a peak temperature of 74c. We did notice some coil whine too, but that could just be related to our sample. It's louder than the impressive TUF cooler, but it's never intrusive. The fact that the FE cooler is even competitive at all given its much lower surface area is proof of its quality engineering.

The 3080 Ti FE is really good card, and it would be an automatic recommendation at its RRP of $1,920 in Australia, but sadly it may never return to Australian shores and it's even less likely to sell at under $2k in the current market. Let's hope that the lowered mining hash rate leads to lower street prices of partner cards and we can go back talking about gaming and exciting tech such as DLSS without the asteroid-sized asterisk that's next to every 2021 GPU review.

SPECIFICATIONS
Nvidia GeForce RTX 3080 Ti Founders Edition; 10,240 Cuda Cores, 1,665MHz Boost Clock; 12GB GDDRX 19Gbps memory, 912.4 GB/s Memory Bandwidth, 3x Display Port 1.4a, 1x HDMI 2.1, 1x1 2-Pin Power Connector, 350W TDP.

The Founders Edition is awesome value. We just hope it remains in the market.

★★★★☆

RRP $3,299 | www.asus.com

Asus TUF Gaming GeForce RTX 3080 Ti OC Edition

Yes, it's possible to have a silent 350W graphics card.

Asus' TUF range of graphics cards have carved out a niche for themselves thanks to their quality coolers, which offer a combination of low temperatures and low noise levels. We really liked the TUF 6800 XT, and if the 3080 Ti version is as good, it could be a 3080 Ti to consider if you're a fan of gaming in silence. The TUF brand, with its focus on reliability as well as its minimalistic design theme is a welcome option for users who aren't impressed by RGB. Its aluminum shroud, solid build quality, custom PCB and its sheer size all point towards a card that's designed to crank out high frame rates, while staying out of sight and out of earshot.

The custom PCB is powered by two 8-pin PCIe power connectors. You get dual BIOS, with a choice of performance and quiet modes. We always do a quick check with both BIOS but given the way the card is all but silent when set to the performance mode we see little reason to set it to quiet mode. You get five display outputs consisting of a pair of HDMI 2.1 ports and three DP 1.4a ports. If you plan to hook the card up to a big TV, a multi monitor setup or a VR headset, this extra flexibility is welcome.

The cooler is the highlight of the card and it performs exceptionally well. Given the price of the card though, anything less would have been a major disappointment. The highest temperature we saw was an incredible 64c which is stunning for card that can draw 350w of power. We thought this might help the card boost a little higher than it did though. After a looping test the boost clocks were in the 1,840MHz range, which essentially matched the FE and Zotac.

The Asus stood head and shoulders above the rest when it comes to noise levels. It was easily the quietest of the 3080 Tis. Though it gives away a little performance compared to the monstrous Aorus, that card is louder and uses more power. The Asus TUF, the Zotac and FE cards all performed within a couple of percent of each other. Asus offers a one-click OC via its GPU tweak software, so you'll be able to grab an extra frame or two of performance if you choose this option, it increases the clock from its out of the box 1,755MHz to 1,785MHz. There's always the higher clocked Strix models to consider too.

SPECIFICATIONS
Asus TUF Gaming RTX 3080 Ti OC Edition; 10,240 Cuda Cores, 1,785MHz Boost Clock (OC Mode); 12GB GDDRX 19Gbps memory, 912.4 GB/s Memory Bandwidth, 3x Display Port 1.4a, 2x HDMI 2.1, 2x 8-Pin Power Connector, 350W TDP.

Asus can always be relied upon to make excellent graphics cards, but as is often the case, they command steep prices. Do you pay extra for the Asus name? The 3080 Ti TUF costs an eye watering $3,299. This compares to the $3,199 being asked of the Aorus Extreme. If you want a truly quiet card, the Asus is the clear pick of the bunch, but the Aorus is the faster and more feature rich option. Which one you go for will depend on which characteristic you value more highly. Like all high-end GPUs on offer right now, we hope that prices will fall in the months ahead. Recommending them in the current climate is tough.

If you're after a quiet 3080 Ti and don't mind paying a premium for it, the Asus TUF deserves a spot on your shortlist.

★★★½☆

apc HOT PRODUCT

RRP $3,199 | www.gigabyte.com

Gigabyte Aorus GeForce RTX 3080 Ti Extreme

Performance first and foremost.

If you want a card to show off to the world, you won't find many better options than the Aorus 3080 Ti Extreme. It takes up four slots, it's fast, it dwarfs almost every other graphics card, it's got RGB, an OLED screen, a PCB for overclocking and no less than six display outputs. It's certainly a card with the lot.

The Aorus 3080 Ti Extreme includes everything plus the kitchen sink. It needs to be held in your hand or compared to another 3080 Ti to get a gauge on how truly big this card is. It's one of few cards to come with no less than six display outputs. These are 3x DP 1.4a, two HDMI 2.1 and a single HDMI 2.0 port. The side LCD panel is customisable and allows you to show real time monitoring info or custom text and GIFs. It's powered by three 8-pin power connectors, it has dual BIOS and lovely RGB lighting. Deciding whether to mount it vertically or horizontally will present you with a tough choice.

Gigabyte clearly decided to build the 3080 Ti Extreme without compromise. The four-slot cooler will rule it out of the majority of compact builds. The triple fan cooler has a lot of surface area. We expected it be exceptionally quiet but actually it proved to be the loudest of the 3080 Ti's we tested. It's not an obtrusive level of noise compared to the insanity of old-style blower coolers, but we had hope for a little bit better acoustic performance. Much like the Aorus 3070 Ti Master, the shroud may be trapping in some excess heat.

The Aorus Extreme was easily the fastest of the 3080 Tis we tested. It averaged a stunning 1,915MHz over our looping test and it did so with an amazing low peak temperature of just 68c. But there's a tradeoff. The cards' fans spin up to very high levels, reaching 81 percent! At this speed the card is clearly audible, but even at this speed the card cannot be considered obtrusive. This performance comes at the cost of very high power consumption of over 400w. That's the highest we've seen from any graphics card we've tested to date. If you want maximum performance, the Aorus is the card to get, but we think the power consumption and noise levels are a step too far.

Enabling the quiet BIOS saved about 10w in power and a produced a slightly lower fan speed but provided no other significant difference. It might be one of the few occasions where we'd recommend setting a flagship card to its secondary 'quiet' BIOS.

The Aorus Extreme is unabashedly a premium card. It demands to be shown off in a windowed case and it should only be matched with a similarly high-spec system. The Aorus might be the Lamborghini of 3080 Ti cards, but at its list pricing at the time of writing it offers surprisingly good value (if that's even remotely possible for a $3,000+ GPU); it's cheaper than the Asus TUF and not much more than the Zotac, but it's not perfect. If noise levels and high power consumption don't concern you or you're prepared to play around with custom fans curves, then the Aorus Extreme is a stunning flagship Ampere graphics card.

SPECIFICATIONS
Gigabyte Aorus GeForce RTX 3080 Ti Extreme 12G; 10,240 Cuda Cores; 1,830MHz Boost Clock; 12GB GDDR6X 19Gbps memory, 912GB/s Memory Bandwidth; 3x Display Port 1.4a, 2x HDMI 2.1, 1x HDMI 2.0; 3x 8-Pin Power Connectors; 400W TDP.

Gorgeous looks, a long feature list and class leading performance make this a 3080 Ti to lust after. It's relatively good value too.

★★★★½

RRP $2,999 | www.zotac.com

Zotac Gaming GeForce RTX 3080 Ti AMP Holo

A good all-rounder in a crowded market.

Zotac is a brand that doesn't get a lot of attention in Australia but it does see limited distribution and its cards are sold though a handful of major retailers. The Zotac RTX 3080 Ti Amp Holo is currently Zotac's flagship 3080 Ti. Its 1,710MHz boost clock is a decent bump over the 1,665MHz of the Founders Edition. The 3080 Ti AMP Holo is a three-slot card but it's one of the few 3080 Ti's that isn't too tall which helps it with case compatibility. If you're a fan of RGB, you'll love it thanks to its bright and vibrant lighting and attractive backplate.

Surprisingly for a 350w card, there are just two 8-pin PCIe power connectors. This means you won't get all that much OC headroom compared to the more powerful OC oriented 3080 Tis with their higher available power limits. Outputs consist of the standard set of three V1.4 DisplayPorts plus a single HDMI 2.1 port.

Zotac's IceStorm 2.0 cooler is longer than that of the FE and this means it lacks a bit of surface area and airflow compared to the likes of the Asus TUF with its huge cooler and larger fans. We noted that the backplate got hot to the touch. Good case airflow is a must.

The Zotac 3080 Ti Holo has a rated boost clock of 1,710MHz but when running a looped test, we saw 1,840MHz during a long run. We saw temperatures in the 74 to 76c range which is very good. The card was clearly audible but not obtrusive. The Zotac IceStorm cooler is well designed efficient. Notably, the card proved to be quite power efficient, using a maximum of 341W, less than the 350W of the FE.

The card performed much like the Founders Edition card. It easily beats out the 3080 non-Ti but at times, like the FE, it seems to be restricted by power limits. We don't have a 3090 on hand to test, but it's safe to say that the Zotac is nipping at its heels. It's competitive with the 6900 XT, too. If we had a market that allowed true price competition, it would be a great time to be hunting for a high-end GPU. It's also worth having a play with the power limits. Manually giving it the maximum 10 percent extra, you'll get better performance subject to temperatures. Using the Time Spy Extreme test, we gained an extra five percent. That's not a game changing gain, but free performance is free.

The Zotac Holo might not have the bells and whistles of the premium tier cards, but it is a worthy alternative to the quality FE card. You get a factory overclock, a superior cooler and its good looks will appeal to RGB lovers and those who like to show off their build. The Holo isn't the quietest card you'll ever come across but that's probably expected given its more compact dimensions. Like all 3080 Ti cards it's very pricey but if you're looking for a solid all-rounder RTX 3080 Ti and you can find one at a good price, the Zotac won't let you down.

SPECIFICATIONS

Zotac Gaming GeForce RTX 3080 Ti AMP Holo; 10,240 CUDA cores; 1,710MHz Boost Clock, 12GB GDDR6X 19Gbps memory, 912GB/s Memory Bandwidth, 3x Display Port 1.4a, 1x HDMI 2.1; 2x 8-Pin Power Connectors, 350W TDP.

The Zotac Holo is a good all-rounder with a relatively good price. It's a worthy alternative to the Founders Edition card.

★★★★☆

Nvidia GeForce RTX 3080 Ti & 3070 Ti benchmark results

Best result
On test

	Metro: Exodus						F1 2020					
	1920x1080 Highest		2560x1440 Highest		3840x2160 Highest		1920x1080 Highest		2560x1440 Highest		3840x2160 Highest	
	Min	Avg	Min	Avg	Min	Avg	Min	Avg	Min	Avg	Min	Avg
Zotac Gaming GeForce RTX 3080 Ti Amp Holo	74.9	137.2	61.5	112.6	45.5	75.0	224	265	185	217	118	138
Gigabyte Aorus GeForce RTX 3080 Ti Extreme	76.7	140.2	65.9	116.7	46.8	77.8	225	269	193	221	126	144
Asus TUF Gaming GeForce RTX 3080 Ti OC	72.8	137.4	60.8	113.0	46.8	74.9	221	267	181	218	120	139
Nvidia GeForce RTX 3080 Ti Founders Edition	71.8	131.4	60.8	112.3	46.6	74.4	221	267	179	217	119	138
MSI GeForce RTX 3080 Gaming X Trio	65.9	127.0	58.1	103.8	41.9	68.0	205	245	167	198	106	124
Nvidia GeForce RTX 3070 Ti Founders Edition	54.7	104.1	46.7	84.0	35.5	54.8	178	217	142	169	87	101
MSI GeForce RTX 3070 Ti Gaming X trio	54.3	104.6	46.8	84.3	35.1	55.2	179	217	144	170	87	102
Gigabyte Aorus GeForce RTX 3070 Ti Master	56.9	106.7	49.3	85.9	35.8	55.6	185	220	148	172	91	105
Nvidia GeForce RTX 3070 Founders Edition	52.8	98.4	44.1	78.3	31.8	50.1	164	204	133	157	78	92
AMD Radeon RX 6900 XT	70.9	127.4	61.6	104.0	43.9	67.8	216	275	171	215	109	133
Sapphire Radeon RX 6800 XT Nitro +	65.1	120.9	58.7	99.2	41.0	63.7	197	256	163	206	104	126
AMD Radeon RX 6800	57.7	102.8	50.0	84.4	35.1	53.9	163	219	135	174	86	105

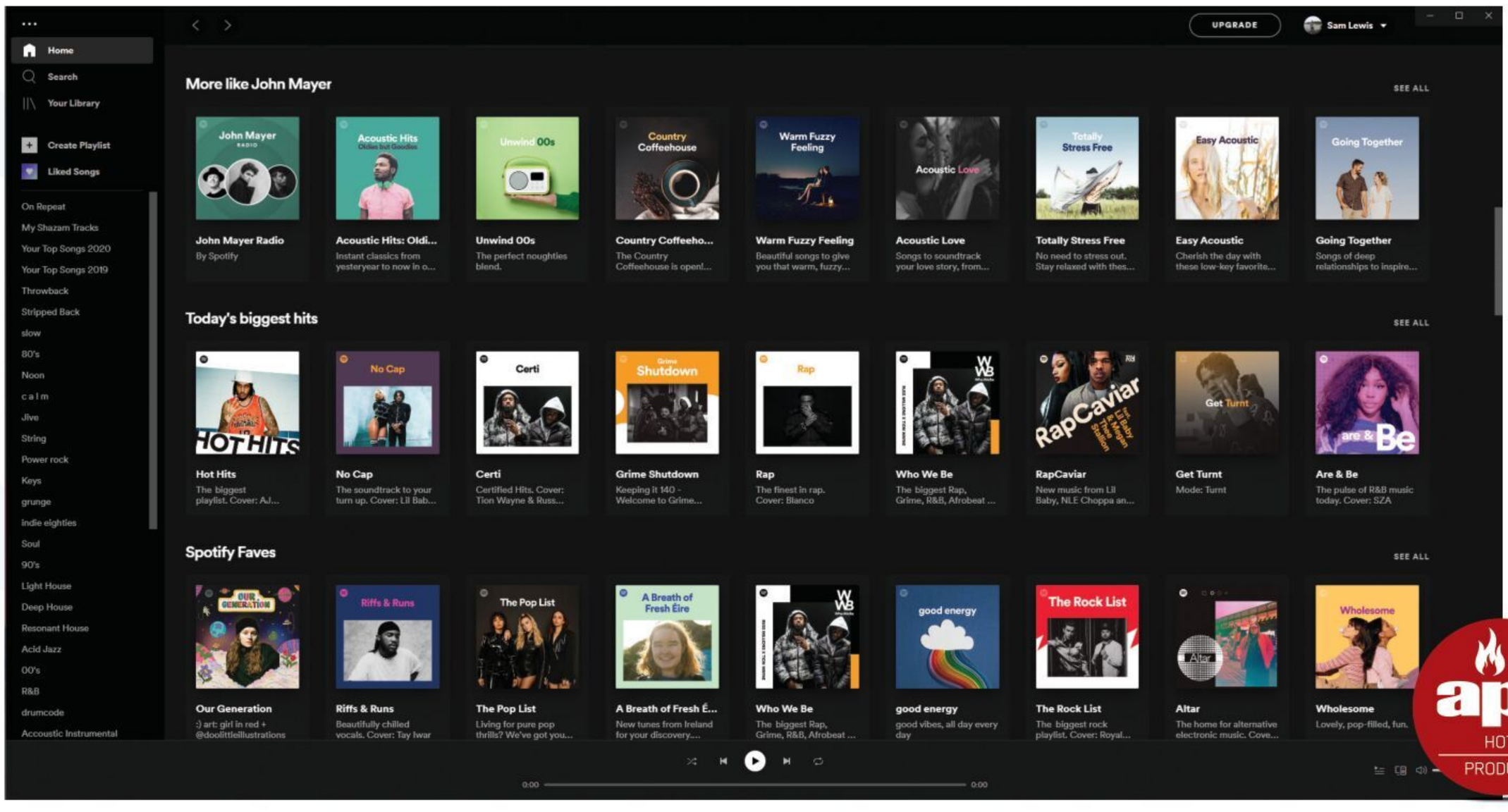
	Middle Earth: Shadow of War						Total War: Warhammer II			Temperatures ©	
	1920x1080 Ultra Avg		2560x1440 Ultra Avg		3840x2160 Ultra Avg		1920x1080 Ultra Avg	2560x1440 Ultra Avg	3840x2160 Ultra Avg		
	Min	Avg	Min	Avg	Min	Avg				Idle	Load
Zotac Gaming GeForce RTX 3080 Ti Amp Holo	59	205	53	162	46	106	124.7	113.1	75.1	37	74
Gigabyte Aorus GeForce RTX 3080 Ti Extreme	58	208	54	167	47	112	123.8	116.7	78.3	36	67
Asus TUF Gaming GeForce RTX 3080 Ti OC	52	207	54	163	48	108	124.5	114.4	75.2	36	64
Nvidia GeForce RTX 3080 Ti Founders Edition	53	206	53	162	47	107	122.5	113.2	75.0	38	74
MSI GeForce RTX 3080 Gaming X Trio	57	193	52	150	38	98	123.6	109.0	66.1	34	74
Nvidia GeForce RTX 3070 Ti Founders Edition	55	167	48	124	37	79	115.8	89.1	55.5	37	79
MSI GeForce RTX 3070 Ti Gaming X trio	53	167	50	125	37	80	116.1	89.1	56.1	37	69
Gigabyte Aorus GeForce RTX 3070 Ti Master	41	172	40	128	35	81	118.7	91.5	56.9	37	66
Nvidia GeForce RTX 3070 Founders Edition	55	156	47	114	33	71	114.4	83.7	50.7	32	73
AMD Radeon RX 6900 XT	63	213	53	164	38	101	124.8	114.9	65.6	44	78
Sapphire Radeon RX 6800 XT Nitro +	47	199	42	152	31	92	122.2	102.6	58.1	43	73
AMD Radeon RX 6800	43	176	41	130	31	77	120.8	91.0	51.7	37	67

	Ghost Recon: Breakpoint			Shadow of the Tomb Raider					
	1920x1080 Ultimate Avg	2560x1440 Ultimate Avg	3840x2160 Ultimate Avg	1920x1080 Highest		2560x1440 Highest		3840x2160 Highest	
				Min	Avg	Min	Avg	Min	Avg
Zotac Gaming GeForce RTX 3080 Ti Amp Holo	127	106	74	179	193	130	158	78	93
Gigabyte Aorus GeForce RTX 3080 Ti Extreme	127	108	76	180	194	136	164	82	97
Asus TUF Gaming GeForce RTX 3080 Ti OC	126	107	74	179	193	132	160	79	94
Nvidia GeForce RTX 3080 Ti Founders Edition	125	105	74	178	189	132	158	78	93
MSI GeForce RTX 3080 Gaming X Trio	122	102	70	170	187	125	152	73	85
Nvidia GeForce RTX 3070 Ti Founders Edition	107	87	54	139	172	103	125	59	69
MSI GeForce RTX 3070 Ti Gaming X trio	108	88	54	140	173	103	126	59	69
Gigabyte Aorus GeForce RTX 3070 Ti Master	111	90	57	147	175	107	129	60	71
Nvidia GeForce RTX 3070 Founders Edition	103	83	49	134	163	95	114	52	62
AMD Radeon RX 6900 XT	126	108	70	169	188	123	149	70	82
Sapphire Radeon RX 6800 XT Nitro +	120	101	64	150	175	111	136	65	76
AMD Radeon RX 6800	111	93	59	133	168	99	122	57	67

	Watch Dogs: Legion (RT & DLSS Off)			3DMark			
	1920x1080 Ultra Avg	2560x1440 Ultra Avg	3840x2160 Ultra Avg	Fire Strike Extreme	RT Feature test	Time Spy Extreme	Port Royal
Zotac Gaming GeForce RTX 3080 Ti Amp Holo	103	88	59	22,766	55.54	8,829	12,912
Gigabyte Aorus GeForce RTX 3080 Ti Extreme	105	89	60	23,432	56.56	9,124	13,418
Asus TUF Gaming GeForce RTX 3080 Ti OC	103	88	59	22,993	55.43	8,899	12,943
Nvidia GeForce RTX 3080 Ti Founders Edition	102	87	58	22,767	55.43	8,838	12,882
MSI GeForce RTX 3080 Gaming X Trio	98	84	55	20,357	49.00	8,194	11,543
Nvidia GeForce RTX 3070 Ti Founders Edition	89	71	42	17,602	33.30	7,051	8,828
MSI GeForce RTX 3070 Ti Gaming X trio	90	71	42	17,621	33.42	7,062	8,877
Gigabyte Aorus GeForce RTX 3070 Ti Master	92	72	43	17,886	34.87	7,160	9,089
Nvidia GeForce RTX 3070 Founders Edition	86	67	40	16,094	32.67	6,459	8,077
AMD Radeon RX 6900 XT	111	88	53	25,012	29.31	8,234	9,698
Sapphire Radeon RX 6800 XT Nitro +	105	84	50	23,110	23.37	7,791	9,051
AMD Radeon RX 6800	95	72	43	20,274	22.05	6,907	7,603

SOFTWARE

APPS FOR ALL YOUR PLATFORMS



Spotify vs. Tidal

Which music-streaming corner should you back?

Before each of the streaming sites starts throwing punches, we need to take a step back to 2011, when the way we consume music began to change. This was when Spotify was widely released and gave the world a new way to experience music consumption. Users could search for and listen to any song that was on Spotify's online library. As a whole, we no longer physically own music; we stream it. Spotify was one of the key founders to push and innovate this new audio age, in which music streaming is a very common household service. For the full packages, you pay a monthly subscription instead of outright physically owning the music – we will dig deeper into this a little later. Since creating this advance in audio listening, Spotify has always been at the forefront of the sector.

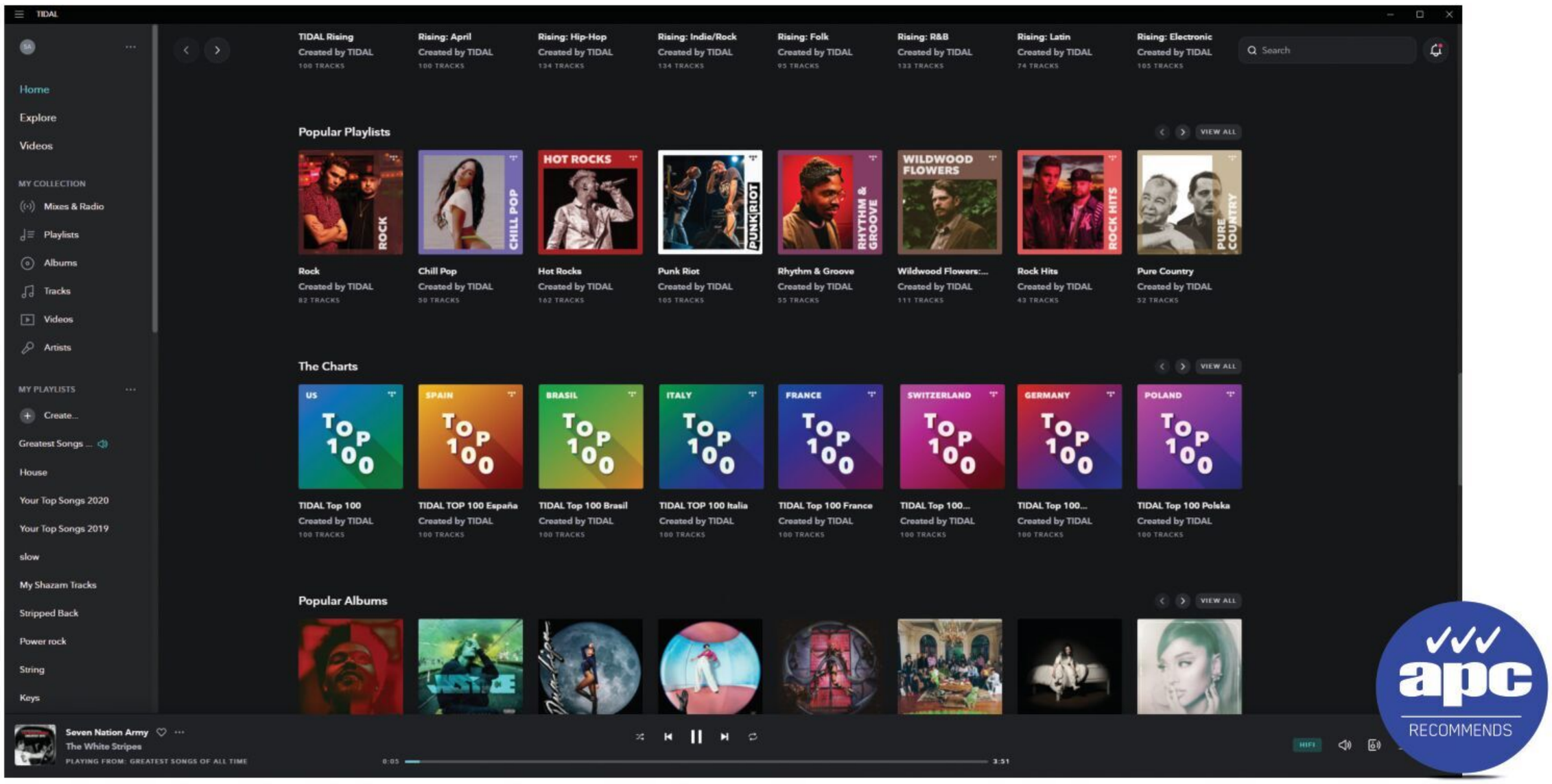
Moving on to 2014, and we have a new competitor in the music streaming industry: Tidal. Artist-owned, Tidal aims to deliver the best sound quality within the audio streaming world. Its partnership with MQA (Master Quality Authenticated) enables it to house the biggest catalog of master audio files. Tidal's been making its name with its focus on audio quality and has been rising in popularity since launch, but where does it stand against Spotify?

Everything you need is right in front of you when opening the Spotify app.

That's the basics covered, but what does Spotify offer the consumer? Well, as well as a library of over 50 million songs, Spotify delivers videos, podcasts, and audiobooks to its audience. Over the years, the software has become incredibly efficient, including features such as Spotify Connect, which enables you to seamlessly switch playback between your devices. Talking of which, the app is super-compatible – you can access Spotify via your PC, Mac, web browser, phone, tablet, speakers, TV, car, games console, smartwatch, and more. That's pretty impressive, to say the least. Seamless integration means that your music isn't interrupted and you can pick up from where you left off. Tidal, on the other hand, takes the short straw regarding compatibility, only being available on PC, Mac, web browsers, and iOS or Android devices. Tidal Connect is a feature that challenges Spotify's seamless nature, but it isn't as fluent as Spotify's pick-up-and-play approach. Where Tidal claims one back over Spotify is its library of music, boasting over 70 million songs – considering Tidal's later entrance into the music streaming scene, you'd have thought Spotify would take the crown here.

Spotify currently has two subscription models: free and premium. The free offering gives you access to the full library of songs, podcasts, and audiobooks, but the audio quality is lower, there are ads, you can't download your music (though you can download podcasts), on mobile devices you can only pick and play songs on specific playlists, and you can only travel abroad with your music for up to 14 days. Premium costs $11.99 a month and gives you access to everything with the highest audio quality it offers and the ability to download and listen ad-free. There are also monthly plans for students ($5.99), families ($18.99 for six accounts), and a duo account ($15.99) for two people living together. Spotify shines when it comes to compatibility, with a user-friendly nature that appeals to the masses.

Tidal isn't as versatile and offers two options, one of which is Tidal Premium, a very similar option to Spotify Premium. The



other is the most desirable subscription between the two platforms: Tidal HiFi. Both the premium plans from each platform offer a music bitrate of 320kb/s at $11.99 a month.

Quality assurance

Where Spotify falls short is audio quality. Spotify HiFi is set to release later this year to challenge this by delivering music in CD-quality, lossless audio format, but this is currently not available – you snooze you lose, Spotify. The HiFi audio that Tidal delivers claims to be "the highest quality audio available" but it costs twice as much as the premium plans, coming in at $23.99 a month. Is the sound quality worth double the price? Teaming up with MQA, Tidal gives the user the best audio quality available via streaming. On its website, it says it delivers music "as flawless as it sounded in the mastering suite and exactly as the artist intended it to sound." The bottom line is that with the right gear (a solid pair of headphones or a hi-fi system with an epic pair of speakers), Tidal certainly gives the consumer a much richer experience. Paired with a DAC, Tidal HiFi is the best audio experience you will get via a streaming music site, but that isn't the full package with these platforms.

Regarding the UI experience, Spotify nails this area. Although the overall aim is to deliver music to the consumer at the best quality possible, these streaming platforms have to do it in an efficient and easy-to-use way. For us, Spotify's layout and design just beats Tidal's; it's a little more vibrant and clear, key factors for a good application. That's not to say Tidal's is bad by any means – in fact, if you switch between the two, you will notice how the layouts are fairly similar, and that's a good thing. Searching on Spotify seems to be more efficient, pulling in what you want. There's nothing worse than remembering a song you love and sifting through the search menus trying to find audio heaven, while trudging through the same old wrong results. Or even worse, giving up because you spelled something slightly differently, resulting in a blank search. This happened very little on both, but more often on Tidal. Luckily, Tidal has an extra trick up its sleeve: It features audio search, a feature that works similarly to Shazam, but built into the app. This is a great time-saving feature, and means you never miss out on finding a song.

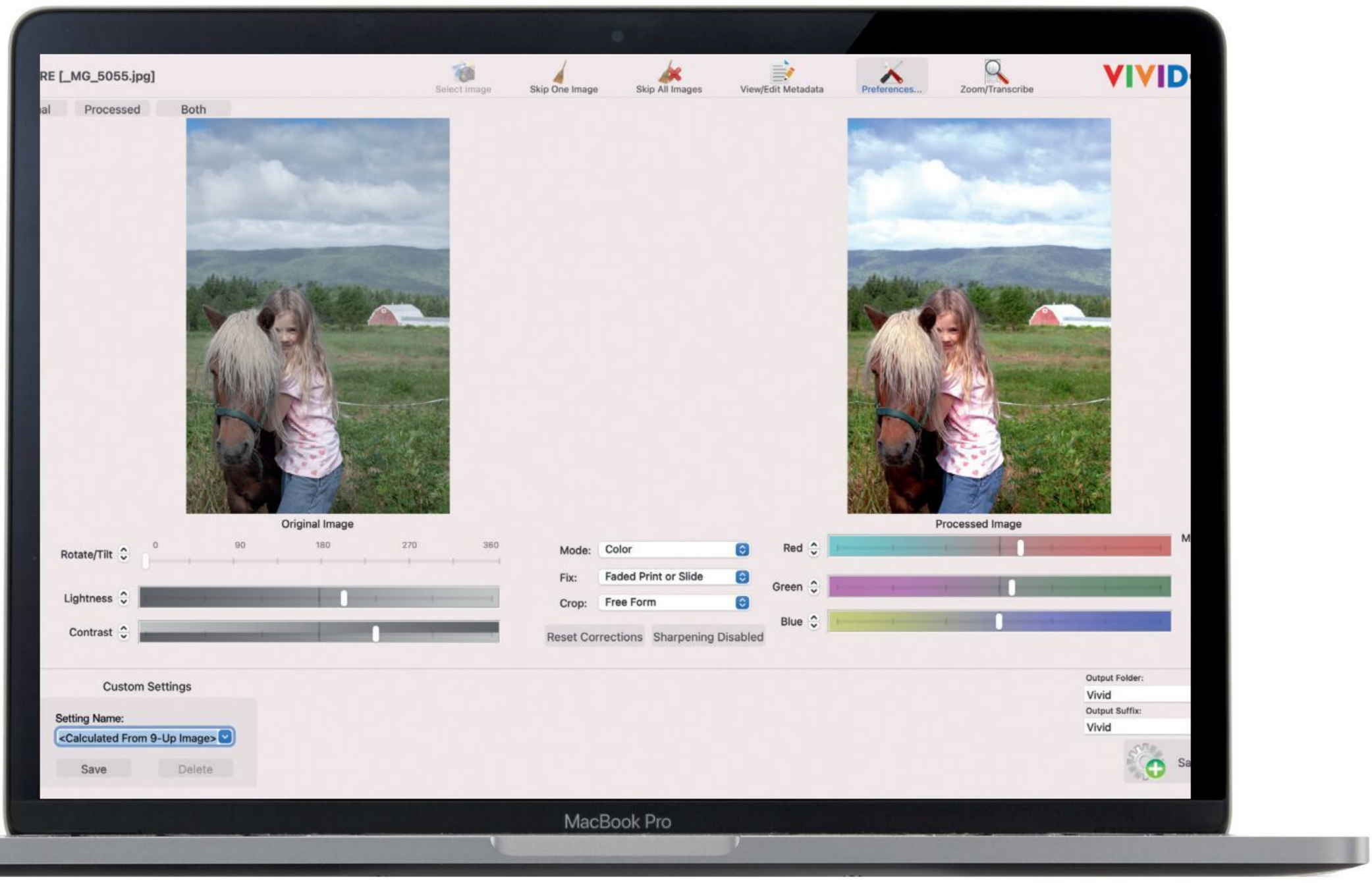
"Tidal will be more than good enough for you as a streaming device. But it isn't as user-friendly as Spotify."

With a similar layout to Spotify, Tidal could make better use of the space.

Both services provide a very similar experience, but each appeals to slightly different audiences. Tidal's artist-driven platform gives more back to the musicians, supporting the creators who make the world a better place with their music. Its focus on audio quality appeals to audiophiles, and if you fit into this category and have all the gear, Tidal will be more than good enough for you as a streaming device. On the flip side, it isn't as user-friendly and efficient as Spotify. With Spotify offering a variety of plans, it appeals more to the masses, and its Premium plan is by no means poor quality. With a HiFi release on the horizon for Spotify, it will challenge Tidal when it comes to being the best at audio quality, and this is an area we will be keeping a keen eye on. Overall, Spotify just beats Tidal, thanks to its more versatile approach to delivering music and slightly better functionality.

SPOTIFY
Extremely versatile platform; seamless playback options; great all-arounder. Doesn't offer the best audio quality.
★★★★½

TIDAL
Best quality music streaming site; search function is not as precise.
★★★★☆



Needs macOS 10.7 or later | US$49.99 | vivid-pix.com

Vivid-Pix Restore (3.1.16)

Bring faded memories back to life.

Thanks to our ever-present iPhone, it's a quick and easy task to snap and share colourful, high-quality images of our daily activities with friends, family, and social media followers. However, many of us have collections of hard-copy photos that are lingering unseen between the pages of old albums or hidden in boxes in the basement. To help your old analogue photos compete with today's pristine digital prints, you'll need to boost their faded colours and restore washed-out contrast. Fortunately, apps such as Vivid-Pix Restore can give vintage prints a new lease of life on our social media feeds.

Restore has a clean and simple workspace. After clicking on the Select Image button, you can choose a setting from the Restore Options drop-down menu to suit your digitised image's particular needs. Options include 'Faded Print or Slide' and 'Digital or Cell Phone Camera'. You are then presented with a grid of nine preview thumbnails showing a range of contrast adjustments. Click on a preview to start your restoration with that particular look. This nine-image preview grid works in a similar way to the preview grids you find in Photoshop Elements when editing colours and tones in that app's Quick Edit mode, and the preview thumbnails for each setting produced similar results using our test images.

After clicking on a thumbnail, you're presented with a before and after version of the image. A collection of sliders enables you to rotate the image and tweak the contrast and lightness settings applied by your chosen preset. If the scanned shot suffers from a cold (blue) or warm (orange) colour cast, you can counteract it using a red/cyan colour slider. Magenta and green tints can be reduced using a second slider. Once a restored print's colours look more accurate, you can boost its saturation using the Vividness slider and click a sharpen button to create a print with more punch.

Easily fine-tune the colour, contrast and sharpness to turn back time.

A selection of preset crop sizes helps you draw a crop window to remove background objects outside the scanned picture's edge. Clicking on the Save Vivid-Pix button pops the restored version into the same folder as the original image in a JPEG format.

Unlike the more expensive Adobe Photoshop Elements, Restore is lacking some advanced restoration features, such as the ability to remove stains and dust spots on prints. Although Restore can rotate and crop a shot, it can't counteract perspectival distortion caused by capturing a print at an angle via your iPhone. However, Restore does a fine job of quickly sprucing up the colours, tones and sharpness of your precious analogue photos and its toolset should be easy for the photo-fixing novice to master.

GEORGE CAIRNS

If using on social media, you can protect your photos by assigning copyright to their metadata.

Vivid-Pix Restore helps you quickly enhance old pictures with ease.

★★★☆☆

Needs iOS 14 or later | $10.99 | readkit.app

ReadKit

The longtime Mac fave is now on iOS.

When it comes to aggregating RSS newsfeeds with 'read later' services like Instapaper, ReadKit has been our go-to desktop app for some time. With support for favourite services, smart playlists, and custom reading controls, there's a lot to love.

Over the years, however, our reading habits have shifted away from the desktop and onto mobile devices like iPhone and iPad, where ReadKit was unavailable – until now. Available on iOS and iPadOS at last, ReadKit is every bit as remarkable as on macOS. That's particularly true on iPad, where the larger display mimics the Mac's three-column layout with subscribed feeds on the left, reader view on the right, and a list of article previews in between.

ReadKit offers support for a total of 15 services, including popular sync providers Feedly, Feedbin, and Feed Wrangler. The iOS version supports the option to import/export subscriptions via OPML, as well as built-in RSS. Although handy when the desktop was an island unto itself, feeds added locally don't sync to other devices. We also had to manually set up services for each new device, since there's no iCloud account sync.

On the desktop, individual subscriptions are configured to sync manually, on launch, or at designated intervals (every five, 10, 30, or 60 minutes). The mobile app takes a more streamlined approach, with On Start, Manual, and Background options. The latter works great – barely impacting battery life – while assuring you can launch the app and browse favourite feeds straightaway.

One downside of many RSS apps is that opening an article displays a truncated version of the text with the option to continue reading on the full website, complete with ads and other unwanted obtrusions. Although we understand the need for this practice (clicks and advertising are a necessary evil), the experience is less than ideal for the reader.

ReadKit extracts full article text, presenting it in a Mac-style three-column interface.

ReadKit for iOS combats this with a built-in reader mode (summoned by tapping the page icon at the bottom) which pulls in the complete text of a selected article in an easy-to-digest view. This works even with tricky sources like *The New York Times*, who otherwise provide a one-sentence description in their RSS feed.

Although ReadKit can share articles to other apps, the app curiously can't do the opposite. Reeder, NetNewsWire, and GoodLinks all support saving web links via a share sheet, so we hope ReadKit will soon do the same. On iPad, we'd also love a way to see every service we've added in the left-hand column (like the Mac app does), rather than having to switch between them.

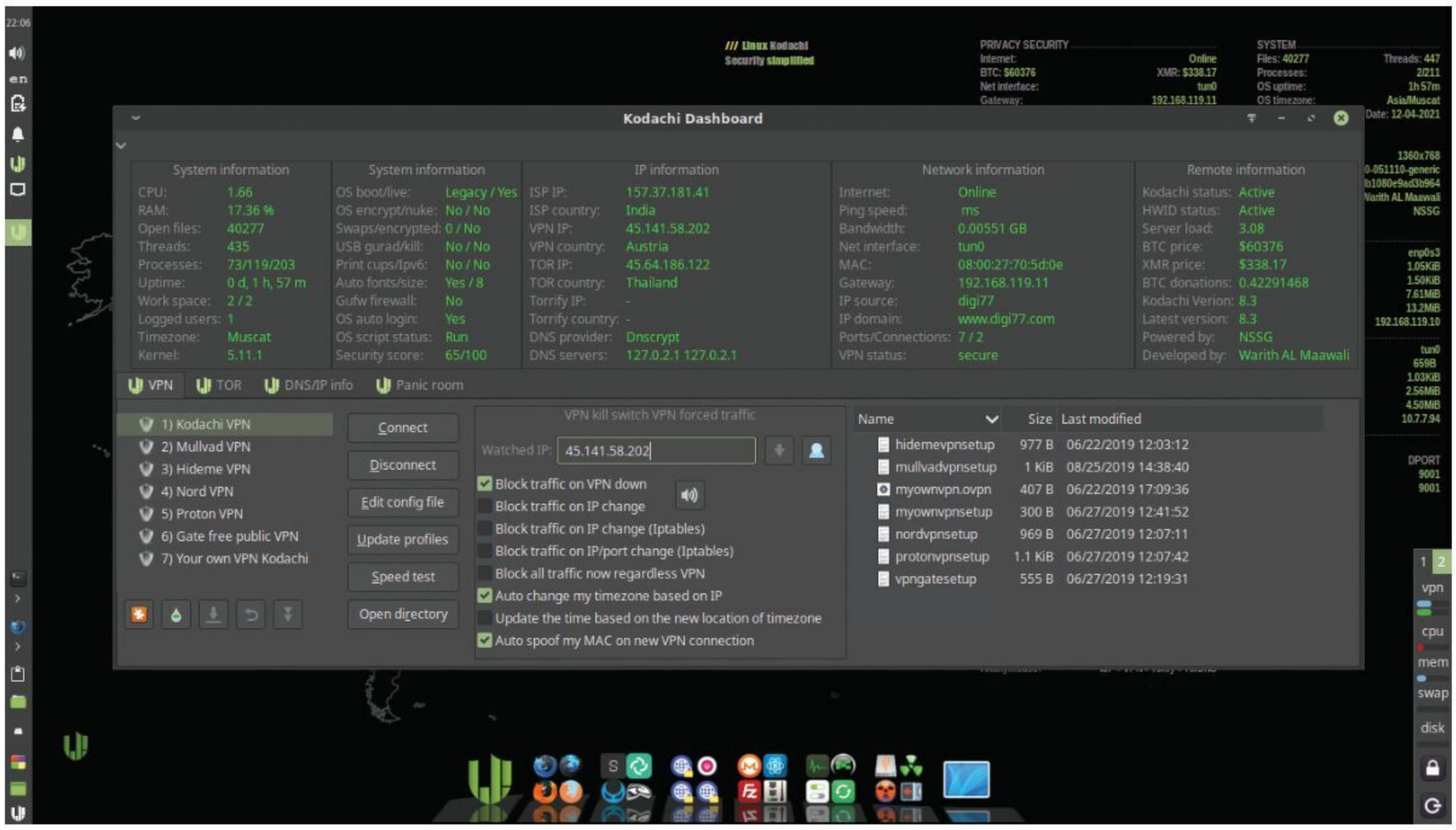
JR BOOKWALTER

"On iOS and iPadOS, ReadKit is every bit as remarkable as on macOS."

Now available on iOS, ReadKit combines RSS with your favourite read later services.

Our go-to news reader app finally comes to iOS.

★★★★☆



One of the useful options in the Panic Room tab is the System monitor. This feature isn't limited to displaying the various logs – it shows all of Kodachi's custom scripts, too.

Linux | www.digi77.com/linux-kodachi

Kodachi 8.3

A self-confessed Kodachi fanboy, Mayank Sharma is left speechless by its latest release and doesn't mind if this review sounds biased (which it is).

T he previous major release of Linux Kodachi saw off competition from its more popular security-oriented peers such as Tails and Whonix. With the latest release, Kodachi further raises the bar with a useful new custom tool that substantially lowers the barrier of entry for the distro and makes it a lot more approachable.

The latest 8.x branch received a few quick updates before settling at v8.3. The 8.x series is based on the Ubuntu 18.04.5 LTS release and its biggest feature is the inclusion of a new dashboard tool.

The release also adds a host of new significant tweaks, and critical functions like VPN and Tor have been made more accessible, while useful features like panic room take on new useful functions.

The distro still boots into a heavily modified Xfce desktop environment that displays plenty of useful information about the system directly on the desktop via Conky applets, including the status and IP address of the VPN, Tor IP, CPU usage, memory and traffic data. It feels a bit cluttered initially, but clock a few hours with the distro and you'll soon realise the usefulness of all the network information available at a glance.

Another excellent customisation is the right-click context menu that bundles useful functions that you can carry out on individual files. The latest releases adds a few more functions including the ability to encrypt and sign files with GPG and OpenSSL.

The distro includes a healthy dollop of well-known and obscure security, cryptography and privacy tools. The release appends a handful of utilities to that list with the OpenSnitch firewall, an EXIF cleaner and more. On top of that it includes all the tools you'll find in a regular desktop distro to function and is more than capable of being used as your daily driver. Even its collection of web browsers are equipped with about a dozen privacy and security enhancing extensions

Kodachi's main attraction is its ability to obfuscate your internet traffic using a combination of VPN, Tor and DNSCrypt. Traditionally, you had to trawl through the distro's menus to bring these systems online.

Starting with Kodachi 8.x, the distro has a neat dashboard utility that exposes some of the most useful functions. Again, it might feel a bit cluttered to first timers, but enabling users to configure various services through checkboxes and clicks is laudable.

The top of the interface displays useful network information, underneath which are four tabs that house all the key editable parameters. Listing the available functions would probably take up half the magazine; suffice to say that we've never seen an easier interface to configure so many VPN and Tor options.

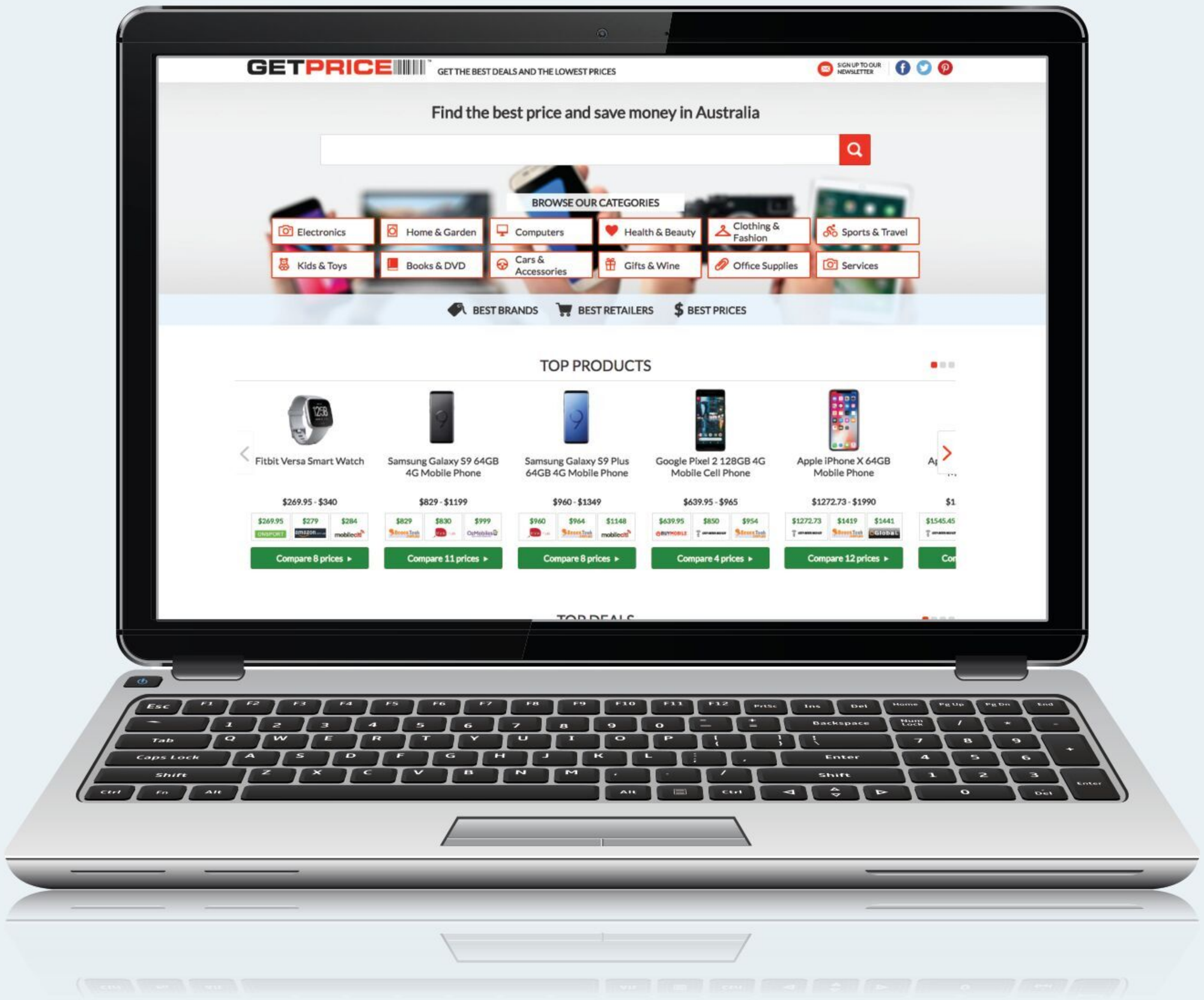
A secure, anti-forensic and anonymous distribution that's designed for privacy-conscious users. Its claim to fame are the many network tricks up its sleeve that enable you to effectively mask your internet connection.

The Panic Room tab offers interesting options to disable various peripherals and adapters including Wi-Fi, Bluetooth and USB, and even destroy the installation with a single click. You can also generate random passwords from under this section.

There's also a System Evaluation option that scores your setup, depending on how you've configured it to route the internet traffic. In fact, you can follow the recommendations of the evaluation script to increase the score and make your system more secure.

We have no qualms suggesting Kodachi to anyone who's interested in privacy and security. It's created by a security professional who has made Kodachi as the ultimate security/privacy/anonymous workstation environment.
MAYNAK SHARMA

By far the most comprehensive distro for privacy-conscious users, the latest release further lowers the barrier of entry.
★★★★½



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UNPACKING INTEL'S ROCKET LAKE & BEYOND

After the Rocket come the Alders, Raptors, and Meteors.

After gazing into broad wells, we've scoured the skies, poked at the kabies (whatever those are), drunk plenty of coffee – in two flavours – then returned to our celestial beginnings with comets. And then there were rockets. If that's as clear as mud, we're talking about the past seven generations of Intel desktop processors, all of which have one thing in common: They're manufactured using a variant of Intel's 14nm process technology.

Granted, today's 11th-gen CPUs, aka Rocket Lake, have about as much in common with the 14nm lithography of Broadwell and Skylake as the latest SpaceX vehicles have in common with the space shuttle, but that's a long time for a company that used to pride itself on alternating between new architectures and die shrinks every year. So, we're peeling back the heat spreader and digging into the underlying architecture to find out what makes Rocket Lake tick. Or is it tock?

Intel isn't done yet, either, and much as Broadwell for desktops was quickly kicked under the rug to make way for Skylake in 2015, there are promising future CPUs coming down the Intel pipeline. We'll discuss what we know of Alder Lake and the upcoming 12th-gen CPUs, and even look at what lies ahead. So, latch your helmet, strap in, and let's shoot for the moon. JARRED WALTON

Backporting Rocket Lake

To understand Rocket Lake, we need to go back to Ice Lake, Intel's 10th-gen mobile-only processors officially launched in late 2019. After an aborted launch of the first-generation 10nm Cannon Lake CPUs in 2018 (no, we don't really count the Core i3-8121U), Intel went back to the drawing board to refine its already-two-years-delayed 10nm process. The result was a reasonably potent architecture, tied to a 10nm process that by all accounts struggled to reach the desired performance levels. Even today, with the server-focused Ice Lake SP launch having just happened, there were clearly some difficulties.

The best and brightest of the Ice Lake laptop chips reached a maximum CPU clock of 4.1GHz. That was the Core i7-1068NG7, a 28W part; the more common Core i7-1065G7 was a 15W configurable TPD chip that topped out at a less impressive 3.9GHz. Perhaps even more concerning, the mobile chips offered a maximum of four cores, with Hyper-Threading allowing eight threads. Back when Skylake was all the rage, that might have sufficed, but the attack of AMD's Ryzen CPUs made such tame configurations look far less impressive.

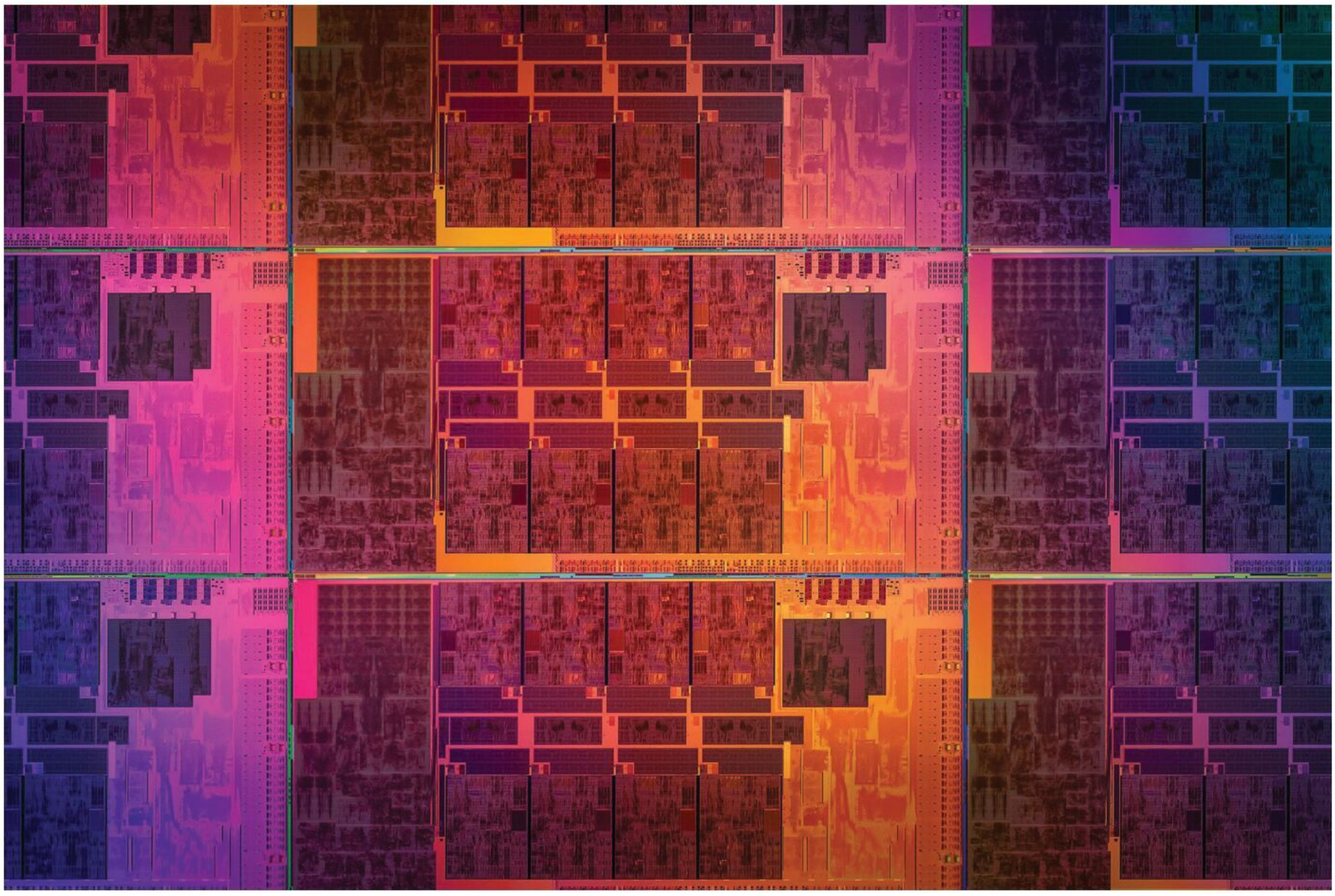
While Intel reworked its existing 14nm desktop offerings to eventually reach eight-core and 10-core chips, it continued to struggle with Ice Lake and 10nm. Ultimately, the decision was made to backport the CPU architecture of Ice Lake to 14nm, which comes with all sorts of difficulties. The Sunny Cove CPU cores at the heart of Ice Lake were designed and built around a 10nm node; returning to 14nm would result in much larger chips, not to mention differences in the lithography rules between 10nm and 14nm. Despite the complexity, however, Intel made the decision to proceed.

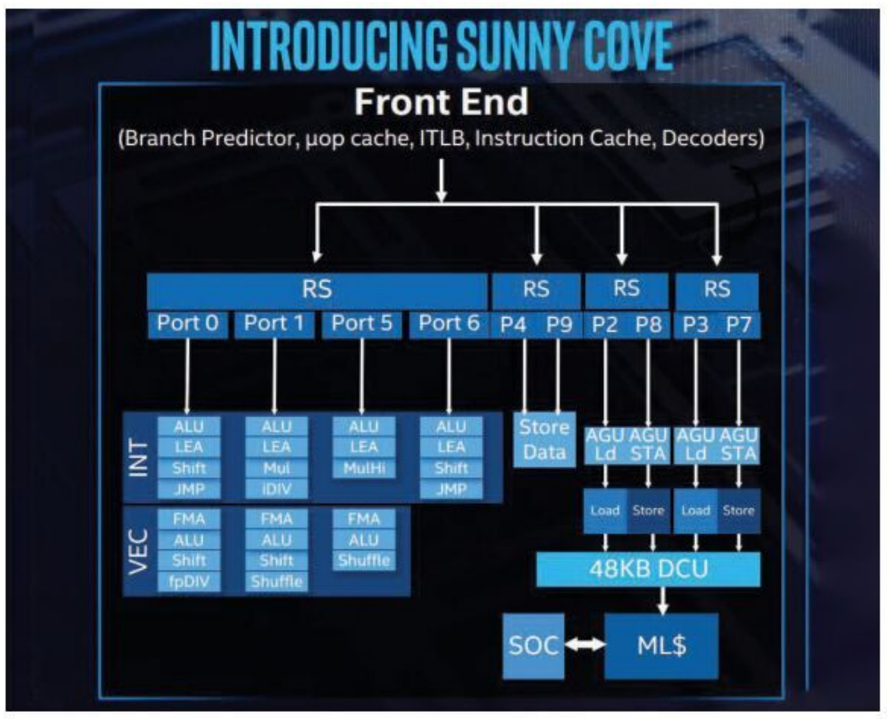
Ice Lake launched in 2019 and only offered mobile processors, but it is key to understanding the rationale behind Rocket Lake.

Pretty on the inside: Intel's 11th-gen Rocket Lake processors are ultimately an exercise in compromise.

The result is the Cypress Cove CPU architecture. It takes many elements of Sunny Cove, then tunes things for 14nm, higher core counts, and higher clock speeds. Also, higher power. Outside of HEDT (high-end desktop) chips like the 18-core i9-7980XE, Rocket Lake is one of the most power-hungry chips Intel has ever created.

The CPU cores weren't the only thing that needed a swift kick in the pants. Intel's 14nm CPUs previously used Gen9 or Gen9.5 graphics solutions. Back in 2015, Gen9 might have been OK, but it can't keep up in 2021. Even the Gen11 graphics of Ice Lake were deemed lacking, and Intel stepped up to the most recent Gen12 Xe Graphics for Rocket Lake. That meant backporting Xe Graphics from 10nm Tiger Lake (the sequel to Ice Lake) to 14nm as well. Here, however, some compromise was necessary. While





The Sunny Cove architecture has lent itself to many of the features of Cypress Cove.

Tiger Lake has up to 96 EUs in the fastest configurations, Rocket Lake is limited to just 32 EUs – it's a painful but ultimately needed compromise.

The biggest drawback of backporting both the CPU and GPU architectures to an older process is size. Intel hasn't revealed official die sizes for the resulting chip, but CPU sleuths have wasted little time in delidding and measuring the die size of Rocket Lake. The previous -generation Core i9-10900K (Comet Lake) offered 10 CPU cores and 24 GPU EUs, and measured around 206.1mm2. The Core i9-9900K in 2018 was an eight-core chip that measured about 180.3mm2, and the six-core i7-8700K from 2017 was just 153.6mm2.

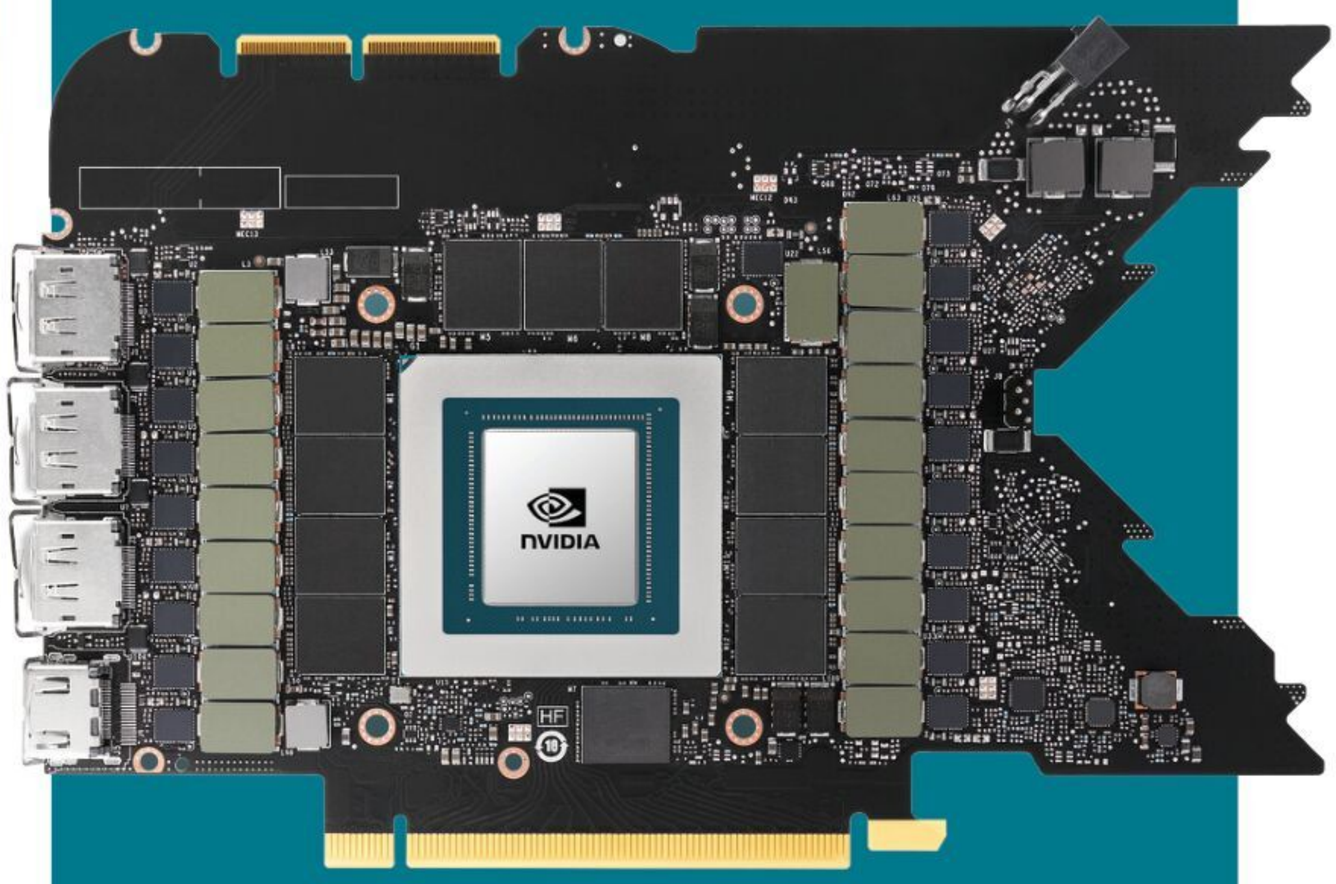
In contrast, the i9-11900K returns to an eight-core design but measures 276.4mm2 – 34 percent larger than the 10th-gen part, despite having two fewer cores. Even worse, compared to the eight-core 9900K, the new chip is 53 percent larger. Granted, some of that comes from having slightly more GPU oomph, but ultimately this is the price Intel had to pay in choosing to backport.

Cypress Cove CPU architecture

The good news is that backporting means Intel can finally leave behind the old Skylake CPU architecture of 2015. Rocket Lake is the first new desktop architecture from Intel since two years before AMD revealed Ryzen – which feels like an eternity ago. Intel claims Rocket Lake delivers up to 19 percent

Intel's Core i9-9900K from 2018 was considerably smaller than today's 11th-gen i9-11900K.

Nvidia's RTX Ampere GPUs utilise an enhanced 10nm node.



WHAT'S IN A NANOMETER?

What originally started out as a rough scale of transistor density and process technology capabilities has morphed into a marketing term as much as anything. Intel has (rightly) noted in the past that its 14nm technology was "better" than many of the competing solutions. TSMC also ended up on the wrong side of the fence with its 16nm node, which it later renamed to 12nm just to look better (with some minor refinements).

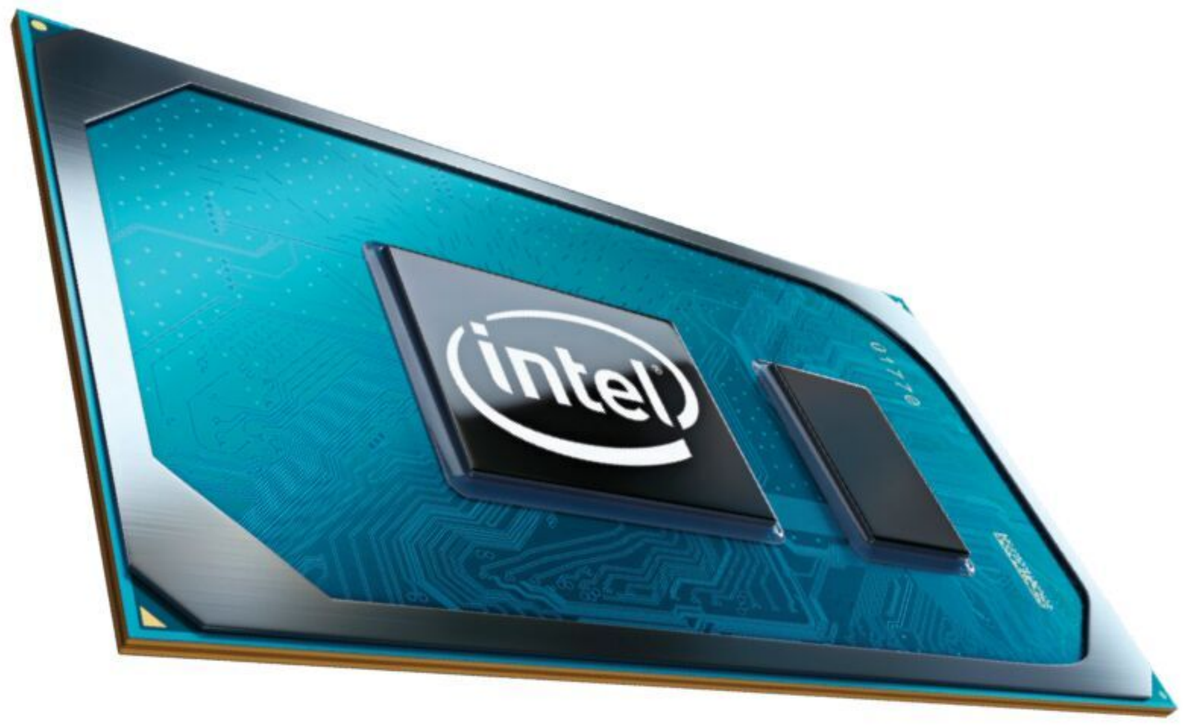
Looking forward, there are numerous manufacturing nodes coming from a variety of companies. Intel has SuperFIN and Enhanced SuperFIN 10nm nodes that are supposed to compete with the 7nm nodes from Samsung and TSMC. The problem is determining which 7nm node we're actually talking about.

Samsung's 10nm node lands between Intel's 14nm and 10nm nodes. It's also shipping 7LPP and second-generation 7LPP, while a special 8N (enhanced 10nm) is currently in use for Nvidia's RTX Ampere GPUs. 5nm 5LPE already went through the risk production back in 2018, and retail products should presumably arrive soonish.

TSMC has the most going on, with N7FF, N7P, N7FF+, N6, and N5 nodes all in production. The various nodes are optimised for power or performance, and N7FF+, N6, and N5 all support EUV (Extreme Ultraviolet) layers. Apple's M1 and A14 chips use TSMC's N5 node.

Within any company, lower node numbers are pretty much universally better, but trying to compare TSMC N7 to Intel Enhanced SuperFIN ends up being far more nuanced. Ultimately, it comes down to density, clock speed, and power characteristics, not to mention yields – as Intel learned, a 10nm node with terrible yields isn't very useful (RIP Cannon Lake).

If you can't get the yields, it doesn't matter that you have a 10nm node.



higher IPC (instructions per cycle) than Skylake, though individual gains will vary. Here's a rundown of the updates Intel made with Sunny Cove, which is largely the same as Cypress Cove.

First, Intel increased the size of the caches, as well as their efficiency. The L1 data cache went from 32KiB to 42KiB, and increased set associativity from eight-way to 12-way. Set associativity improves the efficiency and hit rates of a cache by allowing it to better handle memory addresses that would otherwise overlap. The L2 cache changed from four-way to eight-way, and can be larger, depending on the product. Most Skylake desktop derivatives used a 256KiB L2 size, though Skylake-X derivatives (HEDT) had a 1MB (and 16-way set associative) cache size per core. Rocket Lake strikes for a middle ground with a 512KiB L2 cache size.

Along with the caches, various buffers and other elements are larger, too. The micro-op cache handles 2.25K entries, 50 percent more than the old 1.5K UOP cache. The L2 translation lookaside buffer (TLB) also increased from 1,536 to 2,048 entries. The out-of-order execution window size went from Skylake's 224 to 352 with Ice Lake, in-flight loads improved from 72 to 128 entries, and in-flight stores grew from 56 to 72 entries.

The front end was also made wider, going from four to five instruction allocations, and from eight to 10 execution ports. The L1 cache got twice the store bandwidth, there are four AGUs (address generation units) compared to three on Skylake, and twice as many store operations are available per cycle. To help all areas of performance, Intel also made unspecified improvements to the branch prediction.

Finally, Sunny Cove and Cypress Cove added some new instructions. These include AVX-512, DL Boost for AI Inference, and double the peak throughput for AES-NI (cryptography) instructions. It also supports a larger virtual address space for memory (57 bits, up from 48).

Mix all these improvements together, and you get the 19 percent IPC improvement. The platform also has some new features, such as PCIe Gen4 support for the primary graphics slot and first M.2 slot. Official memory speed support now extends to DDR4-3200 (though we've been able to reach such speeds as far back as Skylake). And topping things off, the width of the interface between the CPU and PCH (platform controller hub, aka chipset) has been doubled, with an eight-lane DMI 3.0 link in place of a four-lane link.

Tiger Lake boasts up to 96 EUs in its speediest incarnations, but Rocket Lake has a paltry 32.

Xe Graphics GPU architecture

Intel hasn't been quite as forthcoming with changes to the graphics architecture, and in fact Xe Graphics, aka Gen12 Graphics, appears to largely build off the existing Gen11 Ice Lake GPU. That's still a big step forward from the old Gen9.5 desktop graphics, however.

The most noticeable upgrade in the GPU department is the move from 24 EUs (Execution Units) to 32, a minimum of 33 percent more computational power, but the underlying EUs feature some improvements that should boost performance more. Clock speeds are also higher, by about 100MHz, but that won't matter much.

The problem is that, even if the new UHD Graphics 750 doubles the performance of UHD Graphics 630, it won't be sufficient for most games. GPUs like the GTX 1050, which we consider borderline for gaming, are still several times faster than UHD 630, which presumably means at least double the speed of UHD 750.

Thankfully, Intel knows this, and it knows desktop users don't really care about integrated graphics performance – that's a way for OEMs and system

Measuring a relatively dainty 206.1mm2, the Comet Lake Core i9-10900K squeezed in 10 CPU cores alongside 24 GPU EUs.

Meanwhile, the i9-11900K has gone back to just eight cores, but still manages to take up 276.4mm2 of space.

Rocket Lake is a power-hungry animal, but not as bad as the 18-core HEDT i9-7980XE.

Despite Rocket Lake's multiple updates, it still can't best AMD's Zen 3 architecture in most benchmarks.

builders to cheap out on the GPU and keep prices lower. Rather than trying to compete with dedicated GPUs it can't hope to match, Intel has focused on other capabilities: The graphics engine includes HEVC, VP9, and SCC encoders that support up to 4K60 HDR, and hardware-accelerated AV1 decode support for 4K60.

While the graphics updates won't necessarily set the gaming world aflame, they should at least prove capable for media-streaming duties.

Can you feel the power?

With the backporting of architectural updates, there's another issue: power consumption. Intel used to be far ahead of AMD in the realm of CPU power requirements, but it's been on a downhill slope with desktop CPUs since 2017. The Core i7-8700K and previous two generations of Core i7s all had a maximum TDP of 95W. Overclocking could exceed that, but even at 5.0GHz the i7-8700K tended to land below 150W. That changed with the 9900K, things got worse with the 10900K, and the situation definitely hasn't improved with the 11900K.

Nominally, the 11900K has an official TDP of 125W, with a PL2 (Power Level 2) rating of 250W. That means that if the motherboard follows the exact limits, the CPU should be able to use up to 250W for a period of time defined as Tau – 56 seconds, in this case. In practice, though, a lot of enthusiast (Z490/Z590) motherboards thumb their noses at such limits and will run at PL2 indefinitely – or at least until the cooler fails to keep up.

Certain workloads can even go beyond official PL2 levels, especially applications that make heavy use of AVX-512 instructions. We saw peak power, running

The Core i7-8700K and previous two generations of Core i7s had a maximum TDP of just 95W – Rocket Lake has a much more voracious appetite.

"stock," of up to 300W during stress testing. Despite the larger die size and greater surface area for cooling, that also resulted in temperatures peaking at 100 C. Thankfully, that's more of a worst-case scenario (Prime95), and it's the price of backporting to 14nm and then running at 4.8GHz on eight Cypress Cove cores.

Also of note is that Intel has further refined its opportunistic boost algorithms. Rocket Lake includes Turbo Boost 2.0, which allows for frequencies of up to 5.1GHz. Turbo Boost Max 3.0 adds an additional 100MHz on the fastest two cores, up to 5.2GHz. Thermal Velocity Boost allows a single favored core to reach up to 5.3GHz, or all-core clocks of up to 4.8GHz, provided the CPU temperature remains below a threshold of 70 C.

Finally, Adaptive Boost Technology (ABT) feels quite similar to AMD's Precision Boost Overdrive. It's dynamic overclocking of sorts, but it doesn't void your CPU warranty. Unfortunately, ABT is only available on the top Rocket Lake chips – 11900/K/KF/F. ABT can kick in as long as the CPU stays below 100 C and works in conjunction with the other boost technologies. It's often disabled by default in the motherboard BIOS, but there's no good reason to leave it off as it's "free" performance.

Failure to Launch

Taken together, all the updates to Rocket Lake sound great, if it weren't for that pesky 14nm+++ process. The net result ends up being less than impressive. AMD's Zen 3 architecture leads in most benchmarks, and the real saving grace for Intel is that, considering the chip shortages, it has inventory relatively available.

There's one redeeming feature in the fact that the Core i7-11700K sports the same eight-core/16-thread configuration as the 11900K, just with slightly lower clocks – and without ABT. But manual overclocking can make up the difference if you want to take that route.

We mentioned that Rocket Lake feels a lot like the Broadwell launch, though, and that's because Alder Lake should release later this year. That's right: We'll get two new desktop CPU architectures this year. But let's douse your enthusiasm by noting that Alder Lake will shift to a new socket, LGA1700 – no upgrades for existing Comet Lake or Rocket Lake users.

Introducing Alder Lake

Intel hasn't been quite as forthcoming with architectural details on its Alder Lake processors, but we do know it plans for a complete suite of desktop chips. Alder Lake represents Intel's first fully featured hybrid x86 processor – well, second if you want to count Lakefield, but this one will be much better.

Hybrid CPU designs aren't new. ARM has been doing big.Little for a decade now, and it's pretty much standard fare for modern smartphone processors. Intel isn't ARM, of course, and x86 cores tend to be quite a bit more complex than even the larger, higher performance ARM cores. Which is perhaps partly why Intel dubs its take on hybrid CPUs "Big-Bigger."

Lakefield used a single large core (Sunny Cove, the same as in Ice Lake) with four smaller low-power Tremont cores. The catch with Big-Bigger is that all the CPU cores must support the same instruction set. Alder Lake takes what started with Lakefield and catapults it into the latest tech. The high-

performance CPU cores use the new Golden Cove architecture, while the smaller cores use the Gracemont architecture. The fastest configuration will support up to eight of each type of core, but that's just the start. Golden Cove is the all-in-one successor to Sunny Cove, Willow Cove, and Cypress Cove. It supports Hyper-Threading, so just on the "bigger" cores that should match Rocket Lake with an eight-core/16-thread configuration. The Gracemont cores don't support SMT, but should provide for excellent power savings, giving a final maximum configuration of 16 cores and 24 threads.

There will also be many lower spec variations, with different numbers of big and small cores. That will create some interesting possibilities, and scheduling within the OS and hardware is going to be a critical factor for performance. That's likely why Intel started with Lakefield, to pave the way for future designs. The lowest configuration is rumored to feature just two big cores (two-core/four-thread), and there will also be a four-core/eight-thread configuration with just four big cores. Models with six or eight big cores will come with zero, two, four, six, or eight little cores.

The hybrid design isn't the only big change with Alder Lake. The more important update is that it will use an updated version of Intel's 10nm process, which it calls Enhanced SuperFIN. That should dramatically improve on the chip size and power characteristics relative to Rocket Lake. There's no word yet on clock speeds or IPC, but with Intel currently trailing AMD, we expect it will try to pull out all the stops.

Alder Lake will take other technologies a step beyond AMD, by being the first consumer CPU to support both PCIe Gen5 and DDR5 memory, or at least that's the current rumour. Those might matter more on servers and workstations, and may not be enabled on all CPUs or motherboards, but we'll have to wait to find out more.

As mentioned earlier, Alder Lake, or 12th-gen Intel Core, will use a new LGA1700 socket. The new socket is required for both the PCIe Gen5 and DDR5 support, and it could include additional lanes from the CPU to other components as well. One thing that isn't changing relative to Rocket Lake: the GPU. Alder Lake will use the same Xe Graphics with up to 32 EUs on the desktop chips. The mobile variants will come in a higher performance GT2 configuration with up to 96 EUs, similar to 11th-gen Tiger Lake processors.

Alder Lake should reunite Intel's desktop and mobile platforms with a single architecture. We're expecting desktop, mobile, low-power, and even Atom-type ultra-low-power designs. Server models are unlikely any time soon considering Ice Lake LP just launched.

If you have an eight-core CPU like the i7-9700K or better in your PC, you might want to skip Rocket Lake altogether.

Looking forward

After years of delays, Intel finally has an updated desktop architecture and new chips rolling out, and it's moving beyond 14nm. All indications are that Intel's SuperFIN already matches up well with TSMC's N7 7nm node, so Enhanced SuperFIN ought to be at least reasonably competitive with upcoming N6 and N5 processes. Intel has far more going on than just Rocket Lake and Alder Lake, of course (see "Many More Lakes" above).

Alder Lake isn't expected until the end of this year, though we suspect Intel will want Alder Lake sooner rather than later. There's no word on TDP or clock speed yet, but we expect it to be far more competitive than what Intel currently offers. If you're already running an eight-core CPU like the i7-9700K or better, or a Ryzen 7 or higher AMD chip, skipping the Rocket and waiting for Alder Lake looks like a reasonable option.

The next Intel versus AMD showdown looks set for later this year or early 2022. By then, Team Red might have Zen 4 CPUs for us, also with PCIe Gen5 and DDR5 support. Rocket Lake didn't quite hit the mark, but Alder Lake is promising, with future 7nm options closing the gap. The next year should be far more exciting in the CPU realm than late 2020 and early 2021, at least. ■

MANY MORE LAKES

Intel is never just looking one generation ahead. Here's a quick rundown of all the other lakes you're likely to see in the next couple of years.

Tiger Lake-H
The four-core models launched in 2020, but eight-core TGL-H should arrive very soon, perhaps by the time you read this. Why didn't Intel just skip Rocket Lake and give us Tiger Lake on the desktop? We're not sure, but we look forward to testing the high-end mobile solution soon.

Raptor Lake
This will be the follow-up to Alder Lake, refining and optimising the architecture. Due in late 2022, the feature set and socket should be similar to ADL, so it will continue to run in LGA1700 boards.

Meteor Lake
This will be Intel's first 7nm CPU offering, except there's even more to it than that. Intel will outsource the production of some Meteor Lake CPUs to TSMC. It will also use Foveros 3D die-on-die stacking, which may partly explain the outsourcing. Intel plans to also manufacture some of these CPUs in-house using its "we've fixed the problems" 7nm process. The socket for Meteor Lake has not yet been revealed, though it will likely end up similar to LGA1700 (maybe with a few pin differences to break compatibility, similar to LGA115x), and we expect this will continue the hybrid design approach.

Lunar Lake
Right now, all we have is a code name that accidentally slipped into some patch notes for Linux. Much as Raptor is to Alder, the assumption is Lunar Lake will be the optimised version of Meteor Lake, perhaps with more chip stacking and other enhancements. Could we see some parts made with TSMC 5nm? Never say never!


AOC

PC Gaming: A History

PC gaming has come a long way. Christian Guyton looks at where it's been and where it might go next.

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It's fair to say that when physicist William Higinbotham started messing about with the trajectory-plotting features of the Donner Model 30 analog computer – a chunky block of metal covered in dials, designed for calculating the flight paths of ballistic missiles – he probably didn't think he was birthing a medium that would eventually come to rival the film and music industries in terms of scale and worth. And yet, in 1958, at Brookhaven National Laboratory on Long Island, New York, that's exactly what he did.

His initial prototype took only a few hours to design and less than a month to implement, using an oscilloscope display to render a simple "ball" and lines, along with a pair of custom-made controllers, each with a single button and dial. Two players took turns hitting the animated dot back and forth, using the dial to control the angle of each return shot.

Higinbotham – formerly a member of the team that developed the first atomic bomb, later a staunch advocate of nuclear nonproliferation – said that he thought his little game would "liven up the place," and he was absolutely right. At Brookhaven's annual public exhibition, hundreds of tech enthusiasts and high-schoolers lined up to play *Tennis for Two*. The display was so successful that an improved version was put on show the following year, allowing players to simulate playing tennis in the low-gravity environments of the Moon and Jupiter. The machine was dismantled following the 1959 exhibition, its components required for less esoteric purposes.

Fortunately, that wasn't the end of it. More than 60 years on, high-schoolers still like pushing buttons to win at virtual sports, but the systems that power those digital matches have evolved beyond anything Higinbotham could have imagined. Last year, *AO Tennis 2* was released, showcasing a fully modernised and breathtakingly detailed tennis experience, right down to the yellow fuzz on the ball and the sweat on Nadal's brow.

The games and computer hardware industries have come a long way in those 60 years, slowly making their way from government-funded labs into our homes and pockets. So, just as Higinbotham charted the trajectory of his tiny "tennis ball," we're going to chart the momentous rise of the PC gaming industry.

Tennis for Two on an oscilloscope and played with two custom aluminum controllers.

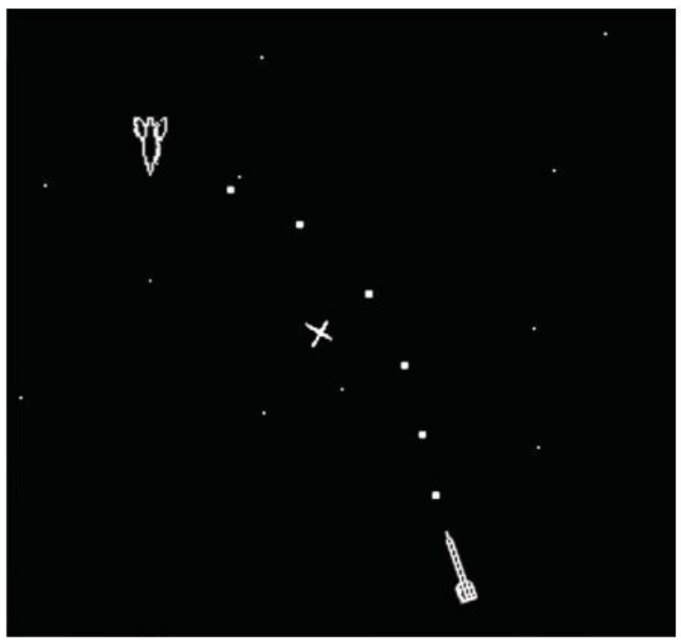
Tennis for Two wasn't exactly the first PC game to be created. For starters, the concept of a personal computer was alien at the time; multipurpose computers with real processing power were huge, while semiconductor technology was still in its infancy. Eight years before Higinbotham created his tiny tennis simulation, Canadian scientists produced Bertie the Brain, a 13-foot-tall behemoth capable of playing tic-tac-toe against a human opponent with varying levels of difficulty. Although Bertie was largely written off as a fun novelty at the time, adjustable difficulty levels remain relevant in games today, more than 70 years later.

There is some dispute as to what the first "PC game" is. Bertie was considered a "game playing machine," but it lacked a proper display, simply using light bulbs and shaped cutouts of Xs and Os. Is this arguably a 3x3 resolution screen? That's not for us to say. *Tennis for Two* cleverly utilised an oscilloscope as its display, but some argue that the first "true" PC game was *Spacewar!*, another two-player game designed by computer scientists at MIT for the DEC PDP-1 minicomputer in 1961.

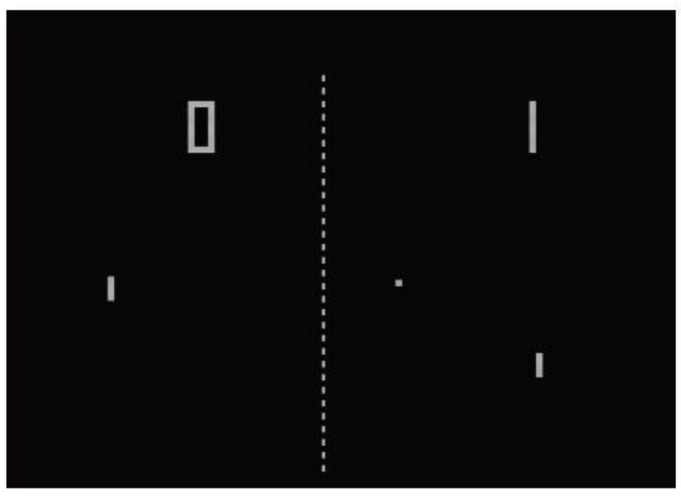
If *Tennis for Two* was the precursor to *Pong*, *Spacewar!* was undoubtedly the inspiration for *Asteroids*. Players controlled two spaceships facing off against each other in the gravity well surrounding a star, everything presented in tiny dots, lines, and polygons on the PDP-1's early CRT display. With limited fuel and missiles, the goal was to destroy your opponent's ship, either with your own weapons or clever maneuvering to force a crash.

While the first version was controlled with the PDP-1's mess of tiny switches, programmer Bob Saunders created the first gamepads ever to exist, to better facilitate two-player games.

Spacewar! enjoyed cult popularity among the computing community in the '60s, helped by the fact that its code was placed in the public domain. Other PDP-1 owners were able to play the game, and it was also ported to later models of the PDP. Some programmers using different computer systems even recreated their own versions. *Spacewar!* was even modified into *Computer Space*, the world's first arcade game unit, ultimately spawning coin-op arcade gaming.



Spacewar! Looks seriously basic now, but it was a huge step in game graphics.



Starting life as an arcade machine game, *Pong* was ported to many early computers.

Home brewed

As advancements in microprocessor tech saw CPUs become more efficient, more powerful, and less expensive, the '70s saw the rise of microcomputers. These were easier to store and use than previous models, creating a template for the home desktop PCs we see today.

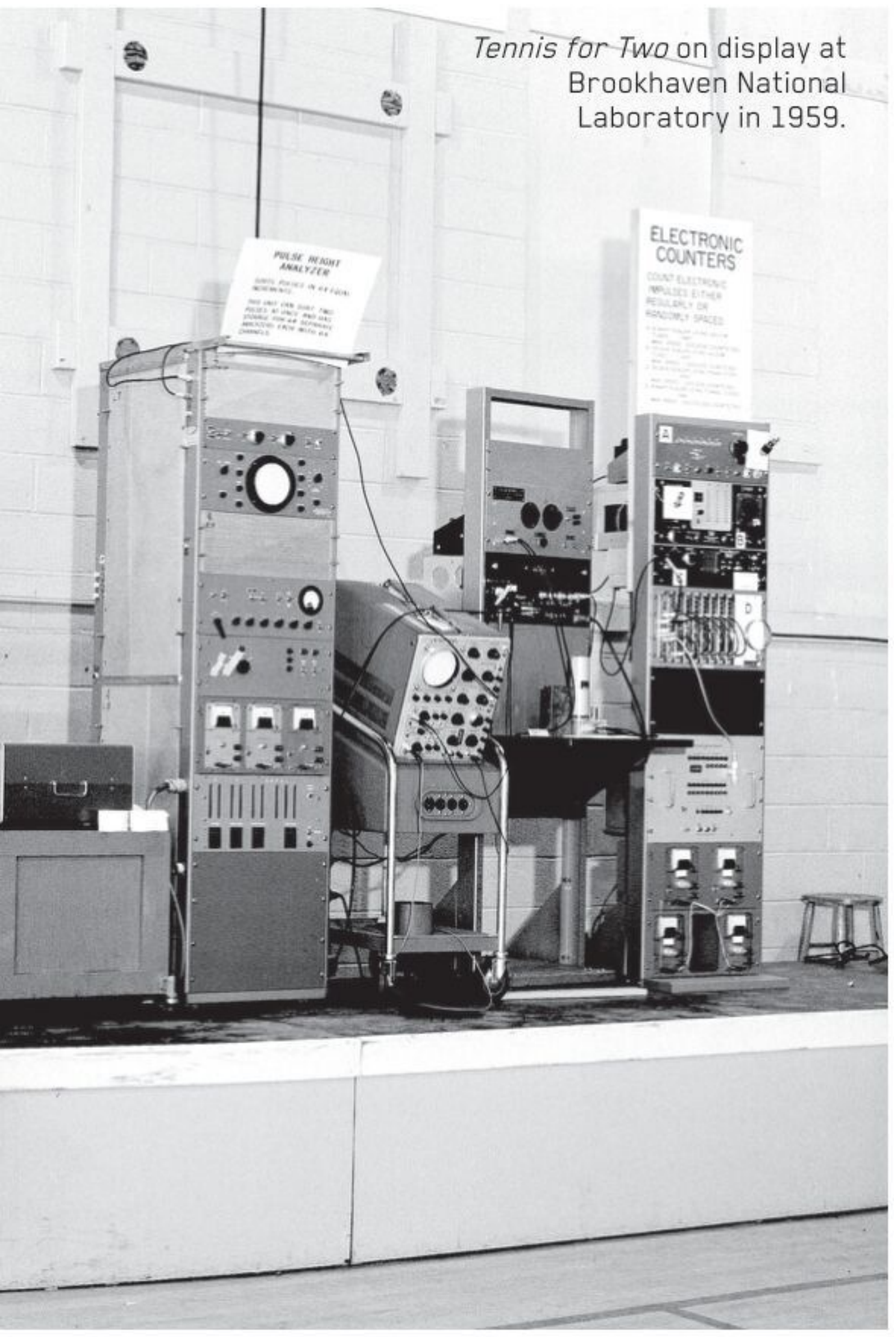
The lower price of admission also meant that computing was further opened up for hobbyists, with software and hardware enthusiasts alike able to experiment and create in their own homes.

We arrived at what could be called the first proper generation of games. One-man unpaid development teams and limited graphical power meant that these early games, produced and distributed throughout the hobbyist community, were primarily simple text-based adventures. Interactive fiction came to computers, taking cues from the cult success of choose-your-own-adventure books. Years later, the genre persists in the form of visual novels (and, yes, dating sims).

The Bard's Tale tapped into the overlap between computer geeks and tabletop role-players.

At this point, the publication industry saw a chance to capitalise on the burgeoning popularity of PC games. *Creative Computing* was one of the first such publications, established in 1974. The magazine came with cassettes containing code for various games and programs, enabling readers to experience a broader variety of games. Creative Computing didn't make it into the 21st century, but the trend persisted, leading to modern-day giants such as *PC Gamer* and, of course, the magazine you're reading right now.

By the time the '80s arrived, the first



Tennis for Two on display at Brookhaven National Laboratory in 1959.

consoles were being sold commercially, with personal microcomputers advancing to a point where real graphical fidelity was starting to become an option. Suddenly, those text-based adventure titles needed to offer more; a backbone of narrative options and role-playing stat sheets was fine, but players wanted to see their characters actually move through these fantasy worlds.

The Bard's Tale – no relation to the 2004 comedy game of the same name – was one of these such games, leveraging detailed pixel art of dragons and goblins to support bulks of text and hidden dice-rolls. Dungeon-crawlers of this ilk were popular, no doubt due to the correlation between computer enthusiasts and tabletop gamers at the time. Most other games that achieved commercial success were ports of already-popular arcade titles, such as *Frogger* and *Pac-Man*. Simple but effective graphics prevailed in these games; *Pac-Man*'s ghosts were tiny, low-resolution sprites with only three colors, but they remain iconic even today.

With serious (well, serious for the 1980s) PCs hitting the market, gamers were spoilt for choice: ZX Spectrum, Commodore 64, Amstrad CPC, and more. Even the Apple II saw a decent share of early game development, long before Steve Jobs decreed that Apple computers aren't PCs and triggered a decades-long divide between Windows and Mac users.

The entry price for home computers at the time was fairly steep, but comparable to a modern high-end PC; most sat between $3,000 and $5,000 in today's money. Budget options weren't really available yet, but for those with the cash, there was plenty of choice. Although the World Wide Web was yet to bring about forums and online multiplayer, magazines, exhibitions, and hobbyist clubs kept the ball rolling. Consoles were here to stay, too, providing a less adaptable but more affordable alternative for those interested in home gaming.

Prior to the 1980s, third-party game developers didn't really exist; most games were produced by the hardware manufacturer's parent company or created unofficially by amateur coders.

It wasn't until the creation of Activision in late 1979 that third-party game studios were born, as a group of programmers broke away from Atari to design their own games and set the precedent for development teams that could work independently of the companies actually building and selling computers.

All good things

As both quality assurance and legal regulation surrounding PC gaming were still in their infancy, low-quality games and rushed clones of popular titles flooded the market. From 1983 to 1985, interest in console gaming plummeted. Some feared that PC gaming would be the next to go, the entire notion of digital games written off as a one-time fad.

Fortunately, PCs are more useful than consoles, and 1983 onward also saw renewed interest in the use of computers for educational purposes. More PCs in households and workplaces meant more potential systems for games to be played on, and the industry was quick to act. IBM released its DOS-based Personal Computer, a game changer within the computer industry that ultimately set the standard for modern PCs; indeed, the IBM PC's primary competition was Apple's original Macintosh computer.

Computer gaming became a booming industry, with companies like the

Console-ation Prize

The console gaming industry has expanded for years alongside PC gaming. We're all familiar with titans such as Nintendo and Sony, but no matter what number comes after the new PlayStation, we're actually currently in the ninth generation of home consoles.

The first console to officially hit the market was the Magnavox Odyssey, which loaded games from "cards," which were essentially PCB cutouts, years before cartridges or disks would become the norm. The Odyssey was only capable of displaying a monochrome line and three dots, and had a total of 28 games, 12 of which were bundled with the system.

Many early home consoles were effectively limited microcomputers using dedicated controllers, rather than keyboards. The Atari 2600 ran with a simple joystick, while the ill-fated Fairchild Channel F used a strange clickable analog stick at the end of a grip. It wasn't until the third console generation that conventional gamepads began to make an impact, with the NES and Sega's Master System popularising the new control method.

Things haven't changed all that much since. The Xbox Series X and PS5 are just gaming PCs in fancy cases running custom operating systems on specially designed APUs. Console game quality leaps forward every few years as the industry stumbles into each new product generation, as opposed to the steady component-based drip-feed of improvements seen on PC.

One area where PC has yet to properly catch up is handheld consoles (although you should check out Alienware's Concept UFO). The growing use of LCD displays in the '80s saw the creation of Nintendo's Game & Watch devices, with the notion finally being brought to fruition in 1989, with the Game Boy. This spawned a series of successful Nintendo handhelds, with fierce competition from Sony for a while with the PSP and PS Vita product lines.

Will handheld PCs one day become the norm? Our phones have certainly become more and more like traditional computers, though we'd like to forget the awkward outing that was the Windows Phone. 5G rollouts mean streaming to a phone or tablet from your desktop PC is a real option, but will we be assembling custom pocket-sized gaming rigs a decade from now? We'd like to see it.

The Magnavox Odyssey certainly doesn't look like the sleek home consoles of today.

Virtual Worlds

Proponents of VR like to claim that it is here to revolutionise gaming, but the technology has actually been kicking around since the '70s, initially used for military and flight training purposes.

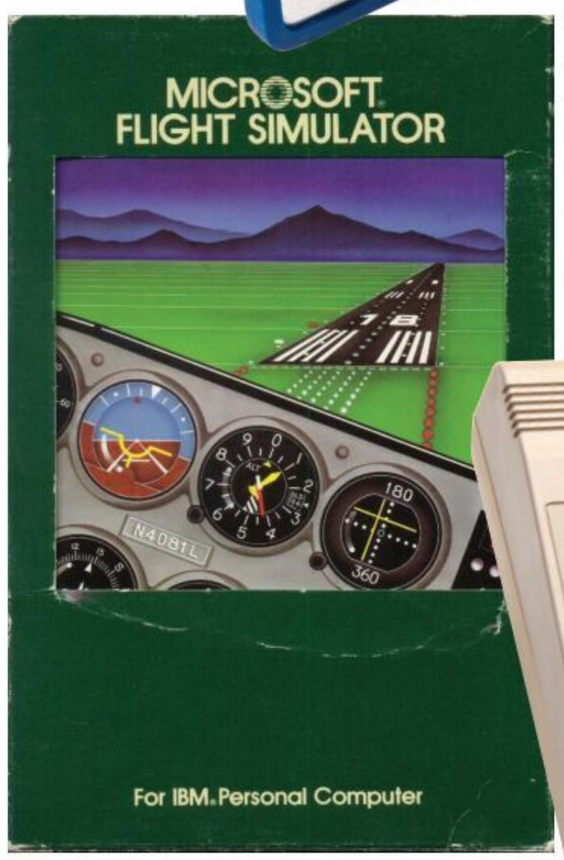
The first VR headsets designed for gaming emerged in the early '90s, when Sega announced a headset for its Mega Drive console. Unfortunately, Sega VR never made it into consumers' homes, with only a half-baked arcade version ever seeing the light of day. A handful of other manufacturers attempted to develop similar technologies, but the gaming public remained indifferent until 2012, when engineer Palmer Luckey and id Software co-founder John Carmack revealed the first Oculus Rift headset at the E3 expo.

The Rift was a revelation for the VR industry. Improved tracking, a wider field of view, and better eye displays meant that it was a serious piece of hardware, prompting a huge resurgence in public interest in VR. The cat was out of the bag. By 2016, more than 200 companies were developing VR-related products. Major competitors, such as HTC's Vive and Sony's PSVR, hit the market. Samsung and Google released headsets that used the player's smartphone as a display and motion sensor, although these struggled in performance compared to "tethered" headsets that connected to a PC.

The release of the Oculus Go (and later the Quest) brought the option of untethered VR, using an onboard Qualcomm chip to render graphics without a PC. The success of 2019's Valve Index says that gamers aren't done with VR headsets that hook up to powerful gaming PCs, but the popularity of the Quest series suggests that as portable gaming tech improves, VR might shift away from PCs and become more like a self-contained console industry.

"The Rift was a revelation for the VR industry. Improved tracking, a wider field of view, and better eye displays meant that it was a serious piece of hardware, prompting a huge resurgence in public interest in VR."

The humble VGA connector. Little did we know it would be the dominant PC game graphics standard for years.



Microsoft's original *Flight Simulator* was popular among office workers, because it could be passed off as a "simulator" rather than a game.

Above top: The original *Doom* is still a blast to play, even if it does look dated. Above: The Commodore 64 was incredibly successful thanks to its affordable price.

fledgling Microsoft producing popular titles such as *Microsoft Flight Simulator*. Unlike today's target audiences of families and young people, office workers were the people buying and playing games, as PCs slowly started to become commonplace in white-collar workplaces. What better way to slack off than load up a copy of *Dig Dug*?

DOS computers started selling like hot cakes. With competition in the market heating up, IBM wasn't able to keep its prices high for long. A wave of IBM PC clones forced prices down, opening up PC gaming to a wider audience. Although still considered a novelty by many, it was undeniable that PC games were beginning to achieve mainstream appeal, with Electronic Arts reporting that many of its customers spent as much as 20 percent of their screen time playing games; even those who had purchased their PCs for unrelated purposes.

Unfortunately, before the end of the '80s, the console market struck back with its coup de grace: the Nintendo Entertainment System, more commonly known as the NES.

The console's vast success in Japan and beyond saw console gaming surge back into popularity, with revenues outstripping the modest successes of the computer game market. Still, the humble PC had two more tricks up its sleeve: VGA graphics and online multiplayer.

Video killed the EGA star

Let's start with why VGA was so important. Before the dawn of the Video Graphics Array, computers – and, by extension, games – had run through several different industry standards for dedicated graphics. In 1981, IBM had the CGA (Colour Graphics Adapter), which was superseded by the EGA (the 'E' stands for Enhanced).

But VGA offered a serious upgrade, with superior resolution, greater colour options, and improved refresh rates. Its 4:3 aspect ratio still kicks around to some degree, and the vast popularity of VGA (and, later, the upgraded Super VGA) among third-party manufacturers made it the new gold standard for PC graphics. Widespread adoption of VGA's 640x480 resolution – laughable today – happened in just a few short years, with IBM shelving plans for a new display controller, the XGA.

Improved graphics coincided with the introduction of dedicated PC soundcards from manufacturers such as Creative Labs (which is still making top notch soundcards to this day), and PC gaming saw a revolution. By the time we arrived in the heady yet poorly-dressed '90s, DOS systems running VGA graphics dominated the computer game market, paving the way for a new kind of game: the first-person shooter.

Texas-based developer id Software was a newly minted company in 1991, but the improved graphical capabilities of PCs enabled it to make *Hovertank 3D* and, a

That's more like it. *Doom Eternal* was the perfect modern update to the legendary series.

year later, the hugely successful *Wolfenstein 3D*. These are the games credited with forming the template for the modern first-person game, some of the first games to place players in a fully 3D world, navigated on a horizontal plane.

Wolfenstein 3D is still fun to play – in fact, 2017's *Wolfenstein II: The New Colossus* featured an arcade machine with a fully playable parody called *Wolfstone 3D* – and it's somewhat surprising how many features of the game have endured in the 30 years since its creation. The first section of the game was available to play for free as shareware, with the full experience unlocked via purchase; a model that would become game demos as we know them today. *Wolfenstein 3D* was also one of the first titles to properly utilise texture mapping, the technique by which detailed textures can be applied to 3D models within the gameworld.

The original *Doom* followed soon after, and achieved even greater acclaim. It wasn't hard to see why: further improved graphics and the fast-paced gameplay fans of the series have come to love (speaking of which, if you haven't played *Doom Eternal* yet, what the heck are you still reading this feature for? Go play it!). *Doom* was a technical improvement over *Wolfenstein 3D* in just about every way, but crucially it offered a multiplayer element.

Bring your friends

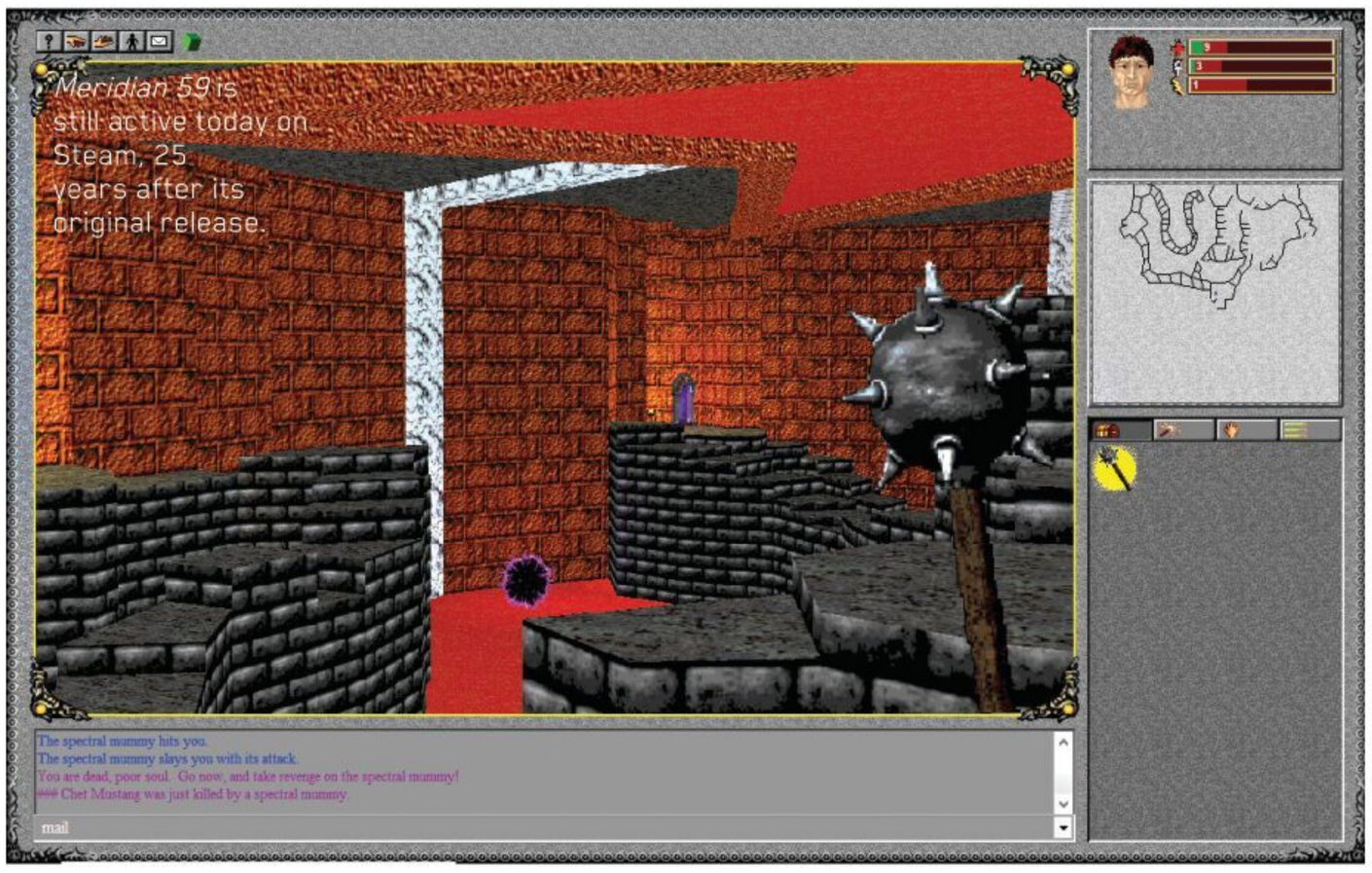
Doom had a variety of multiplayer options, from two-player local co-op to four-man deathmatches over dial-up internet. One *Computer Gaming World* reader wrote in to describe it as "the quickest way to destroy a productive, boring evening of work." Of course, it wasn't the first game to offer multiplayer options (remember *Tennis for Two*?), but it was an important milestone in the development of online PC gaming, which has since expanded into a multi-billion dollar industry.

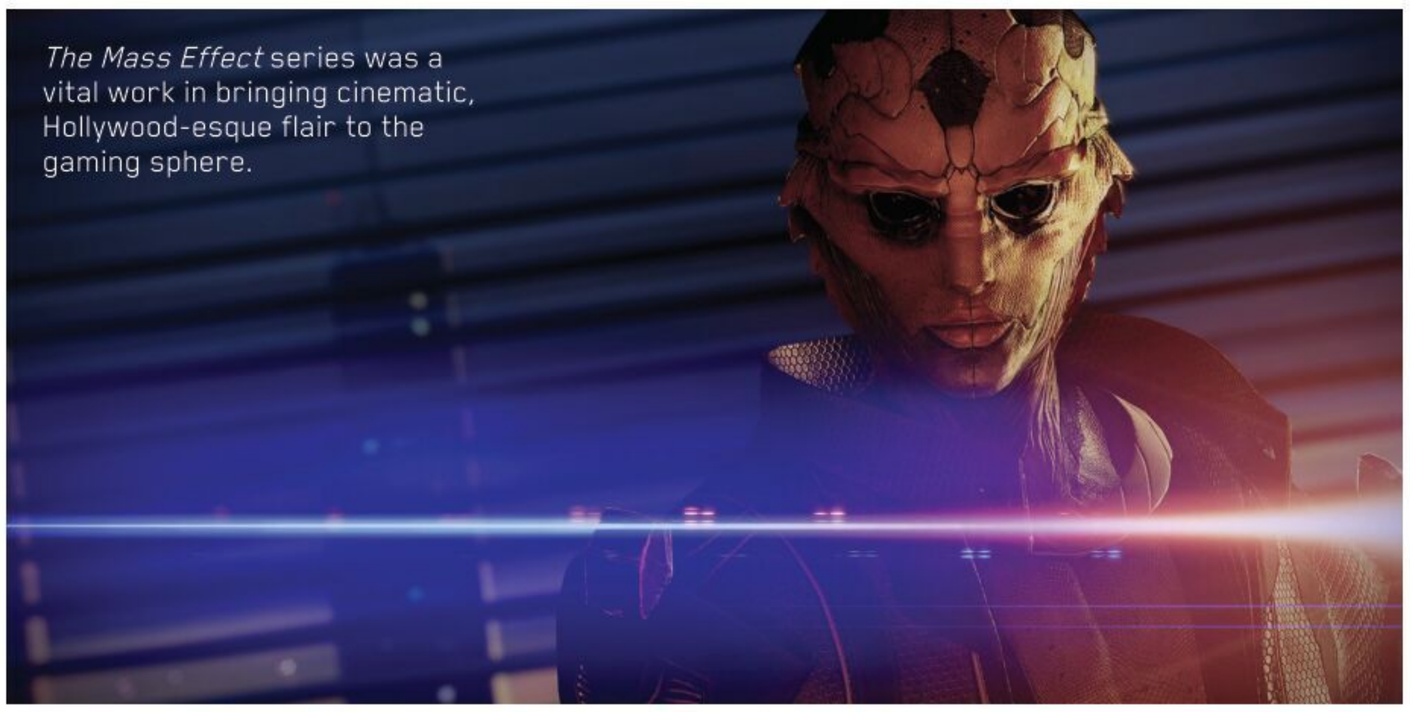
Network play actually dates back to the 1970s, when a group of coders got in trouble for hogging the available RAM of the University of New Hampshire's interconnected network of PDP-11 minicomputers in order to play their home-brew digital *Dungeons and Dragons* campaign. The PDP-11 network allowed multiple users to log into the game from separate terminals, all accessing a segment of shared memory on the university's mainframe computer.

The university banned the games, but the seed was planted – why drag yourself to a friend's house to stare side-by-side at the same screen, when your games could connect remotely? Although the internet was technically created in 1983, it took a few years before it could become a viable platform for online gaming. Multiplayer games set up to run on specifically networked systems grew in popularity throughout the '80s, leading to the rise of the local area network, or LAN, party.

Spectre, released for the Apple

Counter-Strike has seen numerous iterations over the years, catapulting online PC gaming to new heights.





Macintosh in 1991, was a simple game that saw players take control of a little tank, fighting other tanks with missiles and bombs. Using the AppleTalk network service, up to eight users with their own Macs could connect in the world's first LAN game, enjoying hours of fun blasting each other in Spectre's virtual battlegrounds. Some of Spectre's success was attributed to the way it displayed other players' usernames above their blocky avatars; if you wanted to gang up on the cocky player scoring too many points, it was easy to do so. If you've played a *Worms* game in the past decade, you'll know exactly how important that feeling is in fostering connections between players.

With the launch of the World Wide Web in 1991, the industry was ready to expand into bigger multiplayer endeavors. *Neverwinter Nights* was one of the first to set the tone, establishing 96-player servers with chat rooms and persistent world states. One player assumed the role of dungeon master, commanding dozens of other players as they moved through the online world.

With dial-up internet reaching more and more homes, the pressure was on to bring online elements to games. *Doom*'s local co-op success made it an obvious candidate, with id Software adding an online multiplayer update a few years after its release. Titles such as *Meridian 59* further expanded on the template for online games, introducing online guilds and direct player-to-player messaging. *Meridian* is also considered to be the first online PC game to require a regular subscription to play.

The real turning point for online PC gaming, as any gamer who was alive in the '90s will tell you, was *Quake*. Building on the *Doom* multiplayer blueprint, *Quake*'s 1998 QuakeWorld update offered fierce deathmatches perfectly pitched for online play, whether for settling friendly scores in 1v1 duels or just messing around with friends on the weekend. *Quake* was also notable for its early adoption of OpenGL 3D, an intriguing new programming interface for rendering 3D graphics.

New looks

Approaching the turn of the century, game graphics kept making leaps and bounds forward. As computers became more powerful, gamers wanted more from their games; APIs such as OpenGL and DirectX were suddenly sought-after mediums for creating advanced, hardware-accelerated 3D graphics. *Quake* was swiftly followed by Valve's massive breakout hit *Half-Life*.

Half-Life was unique in its insistence on delivering plot beats to the player in real time, rarely taking the player out of protagonist Gordon Freeman's first-person viewpoint. The graphics were good enough that scripted events and bombastic set-pieces could replace the prerendered cutscenes that had become the industry's preferred means of narrative exposition. It was a revolution, and the birth of powerful but more intuitive game development tools, like the legendary Unreal Engine, saw gaming enter the 21st century riding a wave of momentum.

Nvidia and AMD were already locking horns in the graphics card production stakes, and the growing popularity of home PCs (along with the Internet providing the information needed to build your own system) saw the GPU industry boom. No longer were developments in computer tech driving the PC gaming industry; now, gamers drove innovation forward with their insatiable desire for bigger games with better graphics.

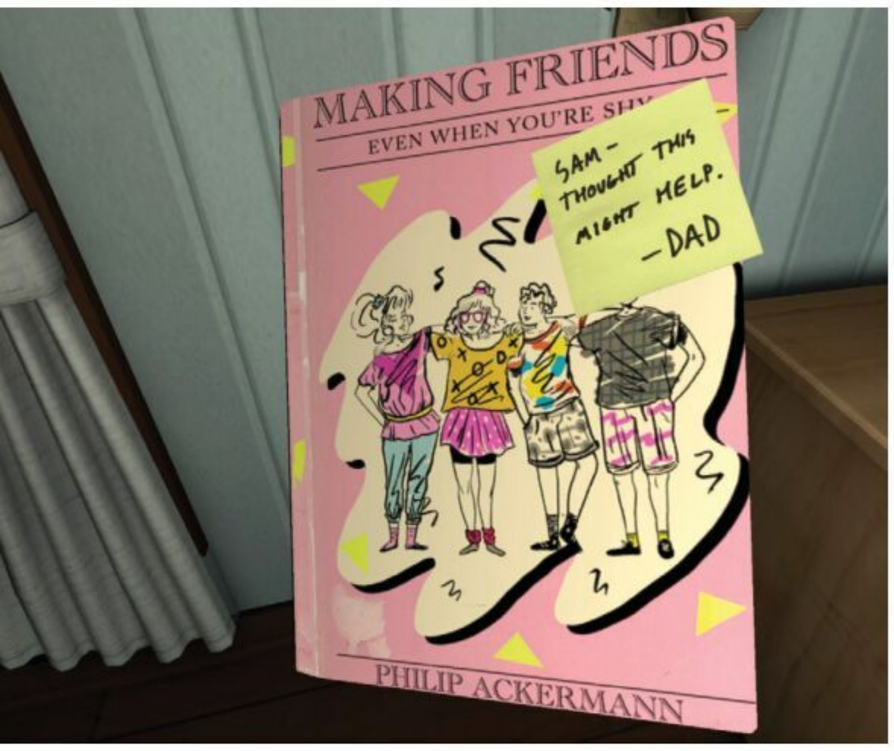
The early 2000s saw a number of hit games land on PC. Although massively multiplayer games were around before *World of Warcraft* kick-started a cultural movement – Neverwinter Nights was one of the earliest, notably followed by *Ultima Online* and *EverQuest* – Blizzard's tour de force drove new interest in PC gaming from tabletop gaming circles and beyond.

Successful multiplayer shooters like *Counter-Strike* continued to make a case for online PC gaming, with consoles (the PlayStation 2 and original Xbox) struggling to keep up. It wouldn't be until the mid-noughties that a new console generation managed to secure wider adoption of online play, while PC gamers enjoyed multiplayer classics like *Battlefield 1942*.

Multiplayer was in vogue; by 2010, every game needed a multiplayer mode. Many were produced largely with competitive multiplayer in mind, while others tacked on competitive play as a half-baked afterthought (looking at you, *Bioshock 2*). Popular multiplatform titles such as *Call of Duty* began to shift away from narrative solo experiences and toward the high-octane bursts of online deathmatches.

Summer sales

Platforms for selling PC games had to evolve. As PC gaming expanded, developers needed easier ways to get their titles into homes, something



Although it features very little actual gameplay, indie darling *Gone Home* has been hugely influential.

faster than mail-order catalogs and cheaper than producing thousands of physical copies. Steam was already around (it was founded by Valve in 2003) but once improved internet access became the norm and the days of the dial-up connection died, home broadband enabled the platform to take over the market.

Competitors arrived in the 2010s, following a blissful few years of Steam maintaining almost complete dominance over the digital distribution market. Some crashed and burned – remember Impulse? But some were able to persist, usually with a clever angle. *The Witcher* developer CD Projekt offered DRM-free games for digital purchase on **GOG.com**, while Blizzard adapted its old **Battle.net** game launcher to sell more games, including some from its partner company Activision.

While some major publishers opted simply to feature their new games as timed exclusives on their own digital storefronts (such as Uplay and EA Origin), others sought to properly challenge Steam.

The Epic Games Store is a plucky newcomer to the digital game distribution industry, but is already ruffling feathers with its free game giveaways and boosted profits for developers.

It's a fascinating situation, especially when the indie game scene gets involved. Developing games for PC has never been easier, and there are far fewer hurdles compared to creating an indie game for consoles, making the PC the perfect medium for a new wave of experimental and innovative game experiences. Epic's decision to take a smaller cut of profits has driven many small and aspiring dev teams to shift away from Steam.

League of Legends has a huge esports scene. Pre-COVID, packed arenas like this were common.

Sport or slouch?

The esports world is a strange beast. Competition is so ingrained in human nature that competitive games have been around since the early days of *Spacewar!*, and real-world tournaments for arcade titles such as *Street Fighter* were popular across the US and Asia throughout the '90s and the early 2000s. The huge success of *StarCraft* in South Korea saw major matches televised for increasingly significant cash prizes. Fighting games, shooters, and MOBAs (multiplayer online battle arenas, such as *League of Legends*) dominated the market, and still do.

Only in the past decade, though, has the esports scene achieved widespread appeal. Major publishers started setting up their own events, while streaming platforms such as Twitch offered new routes into the competitive scene.

The esports formula is something many developers have tried to tap into, with varying degrees of success. For every *Overwatch* and *Valorant*, there is (or was) a *Battleborn* and a *Lawbreakers*. Building the perfect esports game is an art that seemingly has yet to be mastered, but that hasn't stopped the games industry from making its money.

It's been a lot of money, too. The esports industry surpassed a billion dollars in net worth in 2020, and is showing no signs of slowing. COVID-19 actually led to an uptick in interest, with more people picking up gaming in lockdown and turning to professional streamers for advice.

The debate as to whether games can be considered a real sport will probably continue to rage for a few more decades, despite esports becoming increasingly prominent on platforms like ESPN and even being recognised by the Olympic Committee in 2017.

Independent lives

Those indie titles are incredibly important, as they are changing the boundaries of what it means to be a game. The triple-A PC gaming industry has moved away from innovation and toward perfection, constantly chasing the "next generation" of the same tired analogs. We're not disparaging new features like ray-traced lighting or advanced destruction physics, but technological improvements now seem more important than meaningful experiences for players.

Indie games, meanwhile, aren't afraid to think outside the box. Whether it's the tightly-controlled storytelling of *Gone Home* and *Oxenfree* or the potential for players to create their own stories in *Among Us*, indie games offer a tantalising peek into the future of the PC gaming world. Mainstream gaming has become a cash-spewing behemoth; the indie development cycle is a route to break free of corporate obligations, but it comes with its own struggles and pitfalls, too.

Where does PC gaming go from here? It's impossible to predict. The industry has become huge, with millions of gamers and creators looking for their voices to be heard. As we edit this feature, Apple and Epic Games remain locked in a legal battle that could redefine the limits of the gaming industry as a whole, while political bodies are starting to take real interest in games as a form of media and the influence they can hold over the public.

One thing is certain: The money will keep flowing. The industry keeps growing, and games keep looking and playing better. Advances in AI promise to bring a new level of complexity, while augmented and virtual reality offer immersion on a whole new level. We hope home PCs can keep getting smaller and more powerful, and we hope people like you keep building them to play games on. ■

PC BUILDER

WHAT'S HAPPENING IN THE AUSTRALIAN PC MARKET

System news

Computex 2021 revealed much for the PC market this year. Mark Williams covers some of the most exciting highlights.

Computex is always a big item on the calendar each year for new PC tech announcements and products and the 2021 show did not disappoint. Held virtually for the second year running due to COVID, the big three in Intel, Nvidia and AMD had plenty to reveal and show off, leaving us excited for the year to come.

MARK WILLIAMS
Mark is an IT professional with a strong interest in voiding warranties.

Intel

Keen to keep the momentum going with its 10nm manufacturing process ramp-up, Intel unveiled the first of its new Tiger Lake-U refresh processors, bound for 15W-28W thin and light laptops in the coming months. The two processors revealed were the i7-1195G7 and i5-1155G7.

The first will sit at the top of the 11th Gen U-class processor stack, still with four cores and eight threads, but will be the first this generation to boost up to 5GHz. The new i5 also improves peak boost clocks, offering up to 4.5GHz speeds.

Also revealed was the newest NUC. Called the NUC 11 Extreme, the system takes on a larger toaster-sized form-factor of many SFF cases, allowing this NUC for the first time to offer full length GPU support. Enabling the tight 8-litre form factor is a return of Intel's Compute Element platform where the motherboard, CPU, RAM, cooling and other core components are all housed in a compact PCIe card, not dissimilar looking to a short and stocky graphics card. While exact specifications weren't revealed it's known that it'll house Tiger Lake-H processors from i3 through i9s and support SODIMM 3200MHz memory.

Nvidia

In a move surprising no one, Nvidia revealed the new RTX 3080 Ti and RTX 3070 Ti. Apart from now supporting Nvidia's light hash rate (LHR) crypto-mining limiters, these are largely like previous offerings.

The RTX 3080 Ti is more like the RTX 3090 than the RTX 3080 (non-Ti) with just 2.5% less shaders and slightly lower clocked core and VRAM, meaning it's basically a RTX 3090 but at a much more palatable price. And with 12GB of VRAM it is much more suited to 4K gaming than the 10GB of the RTX 3080 ever was.

The RTX 3070 Ti gets a fully enabled GA104 GPU die giving it four percent more shaders than the non-Ti version and most importantly gets VRAM upgraded to GDDR6X, albeit at the same 8GB capacity. All of which means an average performance uplift of 7 percent at 4K resolutions. Both are available now with the RTX 3070 Ti selling from $1,700 and the RTX 3080 Ti from $2,900.

AMD

Announcing what many have been begging for, AMD unveiled the new Ryzen 5 5600G and Ryzen 7 5700G APUs for the DIY market. Releasing on August 5th these APU's will be great for those not needing discreet graphics performance. With similar Vega 8 IGPs to that of the Ryzen 4000G series, the main talking point is the upgrade to the Zen 3 CPU architecture giving the two close to 5600X and 5800X performance respectively.

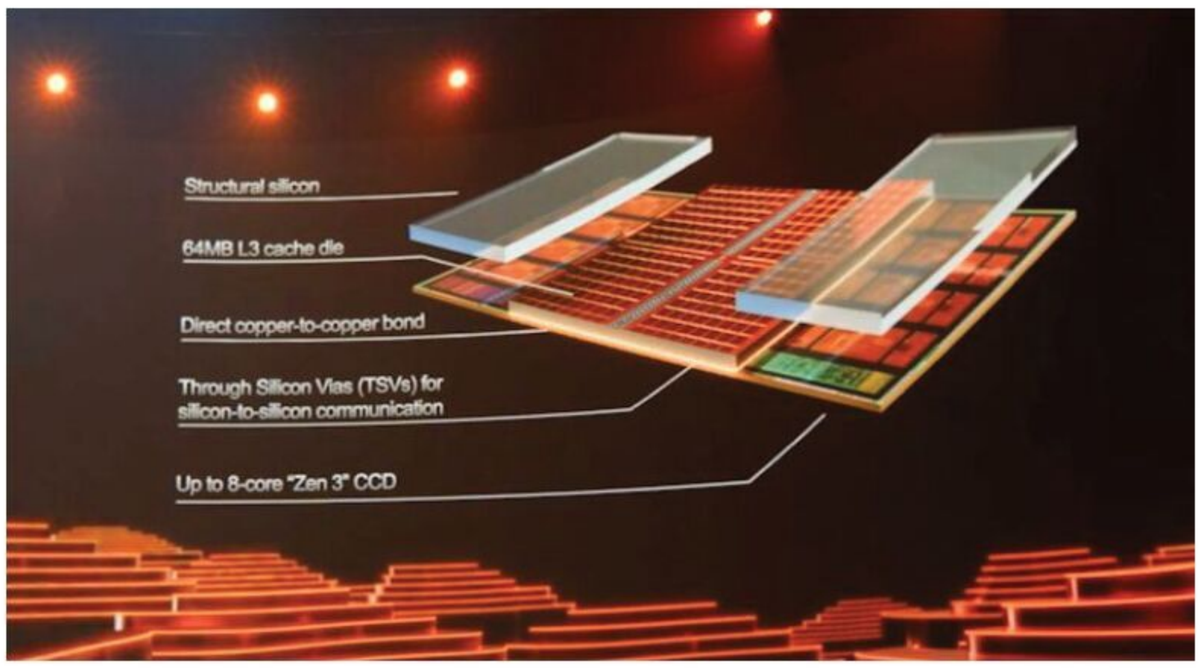
Mobile GPUs also made a splash with the announcement of the RX 6000M series. With RTX 3080 mobile performance levels, the RDNA2 touting RX 6800M will sport up to 12GB of VRAM and has already shown in demo units to stand up well to Nvidia's best. RX 6700M and RX 6600M GPUs were also announced and will cater to the mid and entry level gaming segments.

AMD demonstrated its upcoming FidelityFX Super Resolution (FSR) technology, being AMD's DLSS competitor. Showing up to two-fold performance increases and beyond, it's looking like a very exciting technology that was hilariously shown to also work on Nvidia GPUs that don't support DLSS, like the GTX 1060. What the image quality will be like is another story, but for now this is exciting news.

Saving the best until last, an engineering sample processor was shown with a new stacked 3D V-Cache technology. Essentially AMD is using TSMC's SoIC Chip-on-Wafer technology, enabling AMD to place a 64MB SRAM chip directly on top of the cache portion of a Ryzen 5000 CCD, effectively tripling the cache size of the CCD to 96MB. For dual CCD parts like the 5900X that means 192MB of L3 cache!

Demonstrating the benefits of this, AMD showed a 5900X vs 5900X with 3d V-Cache technology with game benchmarks showing between four and 25 percent higher performance depending on the title. Quite amazing.

Products with 3D V-Cache were announced to be coming by year end, likely in the form of a Ryzen 5000XT line-up. ■



AMD's 3D V-Cache technology stacks relatively huge cache directly on the die, allowing for speed increases of up to 25 percent.

Market snapshot

A sampling of PC systems available this month.

$5,999 | tinyurl.com/APC496CCO

Centre Com Raptor Zen3 3080 Ti

Weighing in as this month's most expensive PC, this system certainly lives up to expectations. Touting the latest Nvidia GPU in the RTX 3080 Ti, you can expect RTX 3090 levels of performance without the extra expense.

The top SKU for the AM4 socket is also inside, giving 32 threads of pure multi-threaded grunt to power through not only games but any productivity tasks you can think of with ease. A top-class motherboard, power supply and copious amounts of RAM make this the perfect system for those that like to work hard and play harder.

The 240mm AIO seems a little small aesthetically for the case and the massive 16-core CPU it needs to cool, be sure to keep an eye on temperatures under extended full core loads, or if overclocking.

CPU: AMD Ryzen 9 5950X **Cooler**: Corsair Hydro Series H100X 240mm AIO **Motherboard**: Gigabyte X570 Aorus Elite **Graphics**: Gigabyte GeForce RTX 3080 Ti Gaming OC 12GB **Memory:** Corsair Vengeance RGB Pro 32GB 3200MHz **Storage**: Samsung 980 PRO SSD 1TB, 2TB HDD **Power Supply:** 750W **Case:** Corsair iCUE 5000X

$5,899 | tinyurl.com/APC496PLE

PLE Computers Cerulean

At just one hundred dollars less than the Centre Com system, it becomes quite a head scratcher why anyone would consider this system over the other. That relatively small extra cost gets you double the CPU core count and SSD capacity over this system, which are quite substantial pluses.

This system has a beefier 360mm AIO cooler that will easily soak up extra heat from any overclocking you might do. This system also sports 3600MHz RAM over the 3200MHz of the other.

Overall, this is no doubt a great system, however the price is a little disappointing relative to the Centre Com system. If you're spending this much on a PC, spending the little extra for the likes of the other system is a no brainer.

CPU: Intel Core i7 11700K **Cooler**: Gigabyte Aorus Waterforce X 360 RGB AIO **Motherboard**: Gigabyte Z590 Aorus Pro Wifi **Graphics**: Gigabyte RTX 3080 Ti Gaming OC 12GB **Memory**: Gigabyte 32GB 3600MHz RGB **Storage**: Samsung 980 Pro 500GB NVMe SSD, WD Blue 2TB HDD **Power Supply**: Unknown **Case**: Nzxt H710i Black RGB

$3,149 | tinyurl.com/APC496ALL

Computer Alliance Alliance Ryzen 5 6700XT

This impressive machine costs quite a bit, but you do get a quite highly-specced parts list in return. Let's look closer. Firstly, the storage is nice and roomy with 1TB of NVMe SSD plus 2TB of HDD capacity. Memory is also impressively sized at 32GB of somewhat over the top (for Intel CPUs) 3600MHz DDR4. The PSU is a good wattage rating at 750W, affording lots of capacity for future upgrades. The water-cooled Intel 10700KF is a generation old now but is importantly only single digits behind in performance to the best in gaming. The star of the show, in the RX 6800XT, will get you RTX 3080-levels of rasterisation performance without costing anywhere near as much. If you're not after ray tracing this is quite a beastly system.

CPU: AMD Ryzen 5 5600X **Cooler**: OEM **Motherboard**: MSI B550M PRO-VDH WIFI **Graphics**: MSI RX6700XT 12GB Gaming X **Memory**: 16GB DDR4 Corsair Vengeance LPX White 3200MHz **Storage**: 1TB Crucial P1 M.2 PCIe SSD **Power Supply**: MSI MPG-A750GF 750W **Case**: Corsair Carbide 275R White

$2,699 | tinyurl.com/APC496PCCE

PC Case Gear Eclipse 6700 XT

With similar headline specs in the CPU and GPU to the Computer Alliance system, this system not only shaves some corners and comes in over four hundred dollars cheaper, but it might also actually perform faster to boot! Ignoring the great CPU/GPU pairing for this price category, this system goes for a B450-based motherboard meaning no PCIe 4.0 support, but the extent to which that affects gaming currently is virtually insignificant. We get a CPU tower cooler that should easily give lower CPU temperatures, and thus longer and/or higher boost clocks, which should lead to generally better performance over the stock cooler. Combined with the ideal RAM MHz rating for Ryzen 5000, this system will outpace the Computer Alliance system in most scenarios. The price of this system, however, makes it the standout winner of the two and a great choice overall.

CPU: AMD Ryzen 5 5600X **Cooler**: Cooler Master Hyper 212 RGB Black Edition **Motherboard**: MSI B450M Mortar Max **Graphics**: PowerColor Radeon RX 6700 XT Red Devil OC 12GB **Memory**: Corsair Vengeance RGB Pro 16GB 3600MHz CL18 DDR4 **Storage**: Kingston NV1 M.2 NVMe SSD 500GB, Seagate Barracuda 2TB HDD

BLUEPRINTS

VALUE- AND PERFORMANCE-DRIVEN HYPOTHETICAL BUILDS

PC BUILDER

Budget

Good.

Things aren't getting any easier on the GPU front, are they? Prices from resellers have dropped a little since our last issue, but stock is still incredibly hard to find, and the aforementioned scalpers are still buying up as many cards as possible. We're concerned that the arrival of the SSD-leveraging chia cryptocurrency will cause a similar shortage of drives, but the western market seems largely unaffected so far.

Speaking of drives, we've got some new additions this month. Western Digital's terabyte WD Blue HDDs are once again cheaper than Seagate's competitor, saving us a few dollars on both budget builds this time around.

We've got new memory for our AMD budget build: 16GB of G. Skill's Aegis RAM at 3,000MHz. The AMD Athlon 3000G CPU is still a steal at $180, and it's 10 dollars cheaper than last month, so be sure to keep an eye on price trends if you're looking to buy.

"Prices from resellers have dropped a little since our last issue, but stock is still incredibly hard to find, and the aforementioned scalpers are still buying up as many cards as possible."

AMD INGREDIENTS

PART		PRICE
CASE	CORSAIR 4000D AIRFLOW	$130
PSU	500W EVGA BA 80+ BRONZE **NEW**	$90
M/BOARD	ASROCK B450M-HDV R4.0 **NEW**	$85
CPU	AMD ATHLON 3000G	$180
GPU	AMD RADEON RX 6700 XT 12GB	$1,100
RAM	16GB (2X 8GB) G.SKILL AEGIS @ 3,000MHZZ **NEW**	$120
SSD	250GB SAMSUNG 980 PRO M.2 PCIE 4.0	$110
HDD	1TB WD BLUE 1TB 7200 **NEW**	$50
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		**$1,925**

INTEL INGREDIENTS

PART		PRICE
CASE	CORSAIR 4000D AIRFLOW	$130
PSU	500W EVGA BA 80+ BRONZE **NEW**	$90
M/BOARD	MSI B460M PRO **NEW**	$105
CPU	INTEL CORE I3-10100	$130
GPU	NVIDIA GEFORCE RTX 3060 12GB	$1,200
RAM	16GB (2X 8GB) G.SKILL AEGIS @ 3,000MHZ **NEW**	$120
SSD	250GB SAMSUNG 970 EVO PLUS M.2 PCIE 3.0	$80
HDD	1TB WD BLUE 1TB 7200 **NEW**	$50
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		**$1,965**

PC BUILDER

Mid-range

Better.

Lots of changes in our mid-range builds this month. For starters, both machines have swapped over to the WD Blue 1TB hard drive, chasing the price drop of the budget builds. Sorry Seagate; we'll come back when your mainline 7,200rpm drive is cheaper. Our mid-range Intel machine has also got a new SSD, since the Corsair Force MP600 is no longer on sale. Its replacement is Gigabyte's Aorus Gen4 drive, a great deal at $150.

Elsewhere, both machines have new power supplies, as we continue to chase the best value for money. The Intel system is now rocking a SuperNOVA PSU from EVGA, while we decided to spring for something funkier in the AMD system: Corsair's RGB-decked CX650-F. RGB lighting on a power supply is something some might turn their noses up at, but Corsair's PSUs are reliable, high-quality products.

We've made some small tweaks to keep the price totals sensible, with a shift from the ARGB model of Enermax's Liqmax III cooler to the standard RGB, and new RAM for both rigs: Crucial Ballistix for the Intel system, and Team Group's collab with Asus for the T-Force Vulcan TUF special edition sticks. These ensure our system memory performance is top-notch without breaking the bank.

Our AMD rig gets a new motherboard this month, too, the MSI MPG X570 Gaming Plus, a solid AM4 board.

Thanks to small price hikes, our AMD build crept up in price by a few dollars this issue. Our Intel machine, on the other hand, managed to shave a few more dollars from the total. The RTX 3070 and RX 6800 XT are still near-impossible to find for a reasonable price, so we can't really advise building either machine right now. That said, if you have an RTX 2000 or RX 5000 card, it could fit nicely into both.

AMD INGREDIENTS

PART		PRICE
CASE	LIAN LI PC011-DYNAMIC	$180
PSU	650W CORSAIR CX650-F RGB **NEW**	$100
M/BOARD	MSI MPG X570 GAMING PLUS **NEW**	$245
CPU	AMD RYZEN 5 3600	$340
COOLER	240MM COOLER MASTER MASTERLIQUID ML240L RGB V2	$80
GPU	NVIDIA GEFORCE RTX 3070 8GB	$1,800
RAM	16GB (2X 8GB) TEAM T-FORCE VULCAN TUF @ 3,600MHZZ **NEW**	$140
SSD	500GB SABRENT ROCKET 4.0 M.2 PCIE 4.0	$120
HDD	1TB WD BLUE 1TB 7200 **NEW**	$50
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		**$3,155**

INTEL INGREDIENTS

PART		PRICE
CASE	LIAN LI PC011-DYNAMIC	$180
PSU	650W EVGA SUPERNOVA 650 GA **NEW**	$130
M/BOARD	MSI Z590-A PRO **NEW**	$260
CPU	INTEL CORE I7-10700K	$569
COOLER	ENERMAX LIQMAX III 240 RGB **NEW**	$80
GPU	AMD RADEON RX 6800 XT 16GB	$1,900
RAM	16GB (2X 8GB) CRUCIAL BALLISTIX @ 3,600MHZ **NEW**	$160
SSD	500GB GIGABYTE AORUS M.2 PCIE 4.0 **NEW**	$150
HDD	1TB WD BLUE 1TB 7200 **NEW**	$50
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		**$3,539**

PC BUILDER

Turbo

Best.

We'd love to tell you that the Intel Core i9-11900K is a sensible purchase right now, but it isn't. Once GPU availability picks up again and the 11th-gen Intel chips drop in price a little, you may want to snap one up. For now, though, we're sticking with the CPUs we've got in these builds. Our Western Digital HDDs are down slightly in price, but this will be temporary as it seems that drives with capacities in excess of 4TB are becoming a little hard to find. So are the GPUs… Well, you know the drill there.

Both of our turbo machines have new power supplies, new motherboards, and new RAM, so let's break it down build by build. The AMD machine has Fractal Design's unobnoxious Ion Gold PSU, a clean, quiet modular power brick from the Swedish manufacturer, plugged into a chunky X570-Plus TUF motherboard from Asus, with 802.11 Wi-Fi and PCIe 4.0 support. Combined with new Viper Steel memory from Patriot.

Over on our Intel turbo build, we've got Nzxt's modular C750 PSU, which made for a very modest saving with impressively quiet operation. The new motherboard is another MSI offering, the Z590 PRO WiFi, a solid Intel 1200 motherboard. Don't look directly at it for too long, though; the monochromatic lines of the design hurt our heads.

The new memory in our Intel system is XPG's Spectrix D41 kit, 2x 16GB at 3,600MHz. Although XPG isn't the first name that comes to mind when we think of RAM, this kit performs well and looks fantastic, with a soft RGB glow. The Intel build also got a new SSD, the 1TB Rocket Q from Sabrent's top-notch M.2 product line, which costs just $180; incredibly cheap for a terabyte of PCIe 3.0 storage.

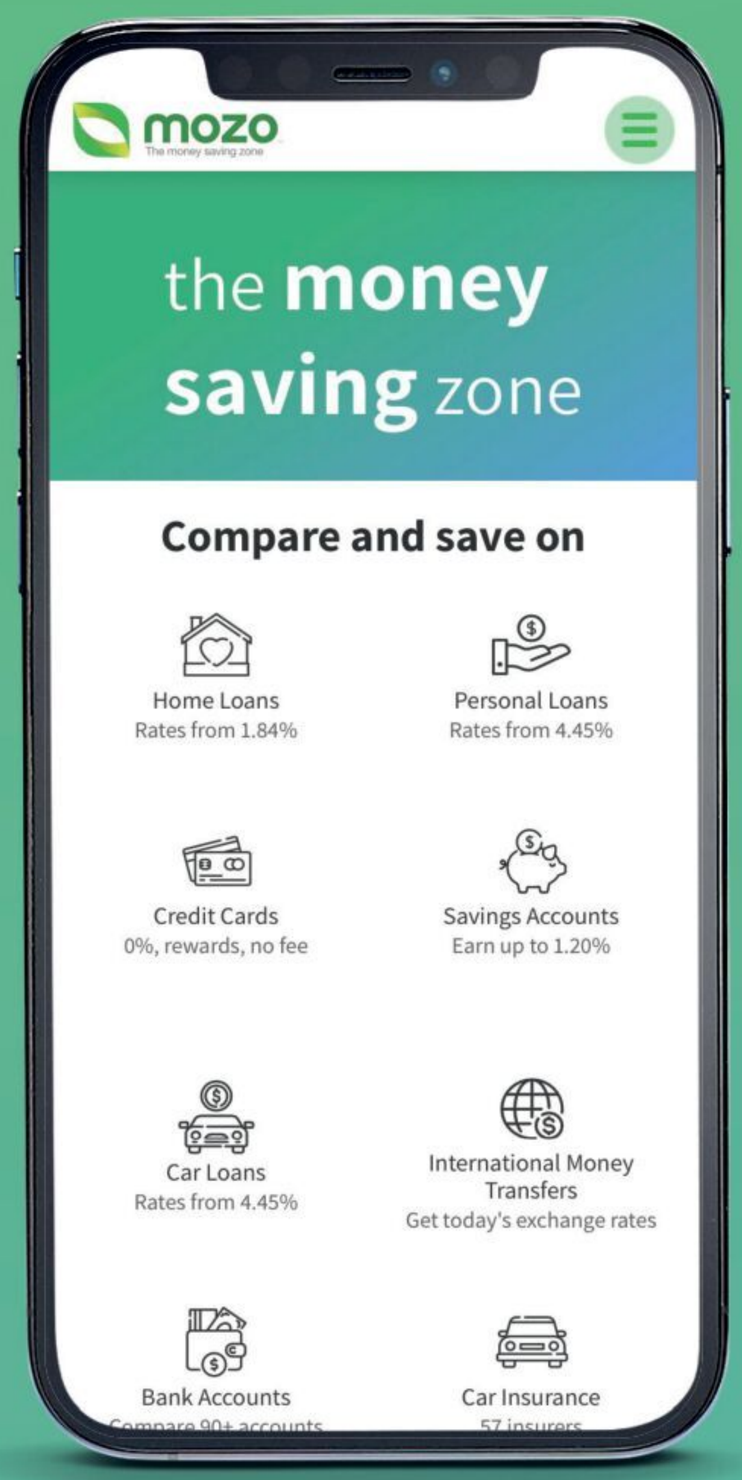
The final addition to these builds is a new cooler for the AMD machine, the Fractal Design Celsius S36. Another 360mm AIO cooler, this bad boy is guaranteed to keep your 5800X running cool. It's not the flashiest of liquid-cooling systems, but it's smartly priced at $250.

AMD INGREDIENTS

PART		PRICE
CASE	PHANTEKS ENTHOO PRO 2 TEMPERED GLASS	$220
PSU	750W FRACTAL DESIGN ION GOLD 80+ GOLD **NEW**	$170
M/BOARD	ASUS X570-PLUS TUF GAMING WIFI **NEW**	$280
CPU	AMD RYZEN 7 5800X	$700
COOLER	FRACTAL DESIGN CELSIUS S36 360MM	$250
GPU	NVIDIA GEFORCE RTX 3080 10GB	$2,100
RAM	32GB (2X 16GB) PATRIOT VIPER STEEL DDR4 @ 3,600MHZ **NEW**	$360
SSD	1TB SABRENT ROCKET 4 PLUS M.2 PCIE 4.0 **NEW**	$250
HDD	6TB WESTERN DIGITAL BLUE	$240
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		**$5,230**

INTEL INGREDIENTS

PART		PRICE
CASE	PHANTEKS ENTHOO PRO 2 TEMPERED GLASS	$220
PSU	750W NZXT C750 80+ GOLD **NEW**	$140
M/BOARD	MSI Z590 PRO WIFI **NEW**	$280
CPU	INTEL CORE I9-10900K	$730
COOLER	BE QUIET! PURE LOOP 360MM **NEW**	$160
GPU	AMD RADEON RX 6900 XT 16GB	$2,200
RAM	32GB (2 X 16GB) XPG SPECTRIX D41 DDR4 @ 3,600MHZ **NEW**	$340
SSD	1TB SABRENT ROCKET Q M.2 PCIE 3.0 **NEW**	$180
HDD	6TB WESTERN DIGITAL BLUE	$240
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		**$5,350**



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PC MASTERCLASS

IT'S TIME TO BUILD A PC.

BUILD IT

The Rocket Lake Gaming PC

Sam Lewis has to fend for himself with his first ever build for *APC*.

PC builds are second nature to us here at *APC*, as you know. We thrive on crafting the finest machines each month, pushing ourselves to the limit to create a build to a specific brief, and challenging ourselves to make a work of art. So, what happens when you put a PC newbie at the helm of a build? Well, you get there slowly. And our journey wasn't plain sailing. Copious amounts of head-bashing, hair-pulling, shouting, and taking parts out and putting them back in took up 99.9 percent of the time spent on this month's build. Our writer, however, has emerged from the experience with knowledge that will stay with them for the rest of their PC building life. The knowledge of what goes where, how to fit everything together, and the importance of practice and an abundance of patience will stay with them forever.

Our photographer, Olly, should thank his lucky stars that he was even able to see the build, let alone photograph it. This was the one time our courier wasn't late, and the one time we didn't want it to be punctual. The build wasn't quite completed in time for collection, and with a tight next-day photography session booked, there was only one way to make it there. Our unfortunate writer decided to wake up at 5 a.m. and drive 4.5 hours to our studio to hand-deliver it. If he doesn't make it in this industry, he'd make a cracking delivery driver. With everything done in the nick of time, we can now get into the build and how it all went down.

PART		STREET PRICE
CASE	NZXT H510 ATX MID-TOWER CHASSIS	$100
MOTHERBOARD	MSI MAG Z590 TOMAHAWK WIFI	$370
CPU	INTEL CORE I9-11900K	$820
GPU	MSI GEFORCE RTX 3070 8GB GAMING X TRIO	$2,000
MEMORY	16GB (2X 8GB) CORSAIR VENGEANCE RGB PRO SL DDR4-3600	$150
PSU	750W CORSAIR RM750X 80+ GOLD MODULAR	$150
PRIMARY STORAGE	1TB SAMSUNG 970 EVO PLUS M.2 PCIE 3.0 SSD	$200
CPU COOLER	CORSAIR ICUE H100I ELITE CAPELLIX 240MM AIO	$170
TOTAL		$3,960

"What happens when you put a PC newbie at the helm of a build? Well, you get there slowly. And our journey wasn't plain sailing."


LIGHTNING GEN4
01.
02.
PCIe
PCIe
msi
GEFORCE RTX
NZXT
VENGEANCE
VENGEANCE

Rocket Lake INGREDIENTS

CPU - $820

INTEL CORE I9-11900K

It may not have the most cores out there, and it might not be the fastest desktop processor around, but this is the best that you can get from Intel right now, and it still packs one hell of a wallop. With eight cores, plus 16 threads of pure backported 14nm performance, it's a monstrous achievement, and credit where credit's due, it still manages to keep up with CPUs of half its transistor size. Aside from that, it also comes with support for PCIe 4.0 drives right out of the gate, packs in a hefty max turbo speed of 5.3GHz, and actually boasts some rather impressive integrated graphics. You know, for when you sell your GPU to buy your next house. It's also, more importantly right now, in stock, making it a valuable asset for anyone looking to actually build a modern-day gaming PC. www.intel.com

GPU - $2,000

MSI GEFORCE RTX 3070 8GB GAMING X TRIO

The MSI RTX 3070 is a tale in itself. It started out life as an amped-up RTX 3070, with a price just a few dollars more than its namesake – nothing out of the ordinary there. It now has a street price of around $2,000. We're hearing multiple reports of wafer prices increasing dramatically, pushing extra costs on to the manufacturing side of things. That aside, the RTX 3070 is fantastic for 1440p, 120Hz gaming and beyond, and the Gaming X Trio provides an epic cooling solution. If the prices return to a normal level, consider picking one up. Just don't pay the street price.
www.msi.com

MOTHERBOARD - $370

MSI MAG Z590 TOMAHAWK WIFI

If you're running the latest-generation Intel processor, it's highly recommended you grab one of the latest boards, too. Z590 is a big part of the Rocket Lake appeal in our eyes, and well worth the investment, unless you already have a fairly high-end Z490 board at your disposal. The increased DMI, native support for PCIe 4.0, and expanded Wi-Fi connectivity will help a ton in the long run. Our MAG Z590 solution here might be pricey up front, but you get a 2.5G Ethernet port, support for Wi-Fi 6E, excellent power delivery, a comfortable amount of USB and onboard connectivity, and a super-slick design, with integrated rear I/O shield, and plenty of shine on top. www.msi.com

RAM - $150

16GB (2x 8GB) CORSAIR VENGEANCE RGB PRO SL DDR4-3600

Memory can be a little tricky to choose. We've seen a slow increase in RAM prices over the last year or so, but nothing quite like the boom in other components, 7nm or otherwise. We've decided to opt on the side of budget for this build, however, and grab a 16GB kit of Corsair Vengeance RGB Pro SL, running at 3,600MHz, with a CAS latency of 18. It's a new product, launched earlier this year from Corsair, and it comes with some updated lighting and better overall performance. 3,600MHz might be a touch excessive, given that Intel is not quite as dependent on memory speed as Ryzen, but for rendering applications and light Photoshop work, it'll help out significantly. Is 16GB enough, though? Well, it depends on your personal computing habits. If you're a minimalist and like to keep your desktop clean and workspace mostly empty, then it's going to be plenty. However, if you need to have 32 Chrome tabs, Discord, Slack, Google Chat, 28 other background programs, and the latest AAA title all running at the same time, then opting for the slightly more expensive 32GB kit might be a better choice.

www.corsair.com

PSU - $150

750W CORSAIR RM750X 80+ GOLD MODULAR

We're keeping things simple for our power supply and going with a fully modular 80+ Gold solution from Corsair. Its RM series of power supplies has long been a favorite across the PC-building community, and with good reason. With a fantastic 10-year warranty and excellent noise characteristics, along with modular cables, it's a mainstay among enthusiasts on a budget. Corsair's latest 2021 edition features updated internals, better temp management, a magnetic levitation fan, and some impressive load temps, too. We expect this rig to pull around 475W from the wall, meaning even under extreme load conditions, fan noise should be kept to a minimum, thanks to some zero fan tech. The only thing we'd change about this setup in hindsight? Maybe some custom cables, too. www.corsair.com

CPU COOLER - $170

CORSAIR ICUE H100I ELITE CAPELLIX 240MM AIO

In this build, we've gone with a trusted favorite of ours for the CPU cooling duties, namely the iCUE H100i Elite 240mm Capellix from Corsair. This wee beastie is the latest from the Californian giant, and packs in a slim rad, a set of hefty aRGB fans, and a Capellix LED-lit waterblock. These things are bright – seriously bright – and super-small, too, giving your cooler some extra pep and helping turn it into the centerpiece of your build. We'll be running this at the front of the case, with our fans in a push configuration, drawing cool air in the front, then exhausting it out of the back. By default, the H100i Elite supports pretty much every major socket type from both AMD and Intel, and comes in at a fairly reasonable price, too (given the silly LEDs sitting in the middle). You can also swap out the CPU block plate for an included white one instead if the stock style isn't quite for you. www.corsair.com

HDD - $200

1TB SAMSUNG 970 EVO PLUS M.2 PCIE 3.0 SSD

We've gone fairly minimalist with our SSD pick, with a single 1TB M.2 PCIe 3.0 SSD: the Samsung 970 Evo Plus. The reason we've picked this over its 980 Pro PCIe 4.0 cousin is twofold. Firstly, we're rather worried that by the time you read this, chia coin and its SSD-dependent farming will have hit the market hard (hopefully not, but there's no way of knowing), and if that's the case, this particular drive may still be readily available, or more so than its speedier cousin, at least. And secondly, it's slightly cheaper now, too. As our primary aim here is a gaming PC, 1TB of PCIe 3.0 storage will be more than enough for quick load times. However, if you can stump up the extra cash, and it is in stock and not being farmed out for more non-physical currency, grabbing the 980 Pro would definitely be a better bet. www.samsung.com

CASE - $100

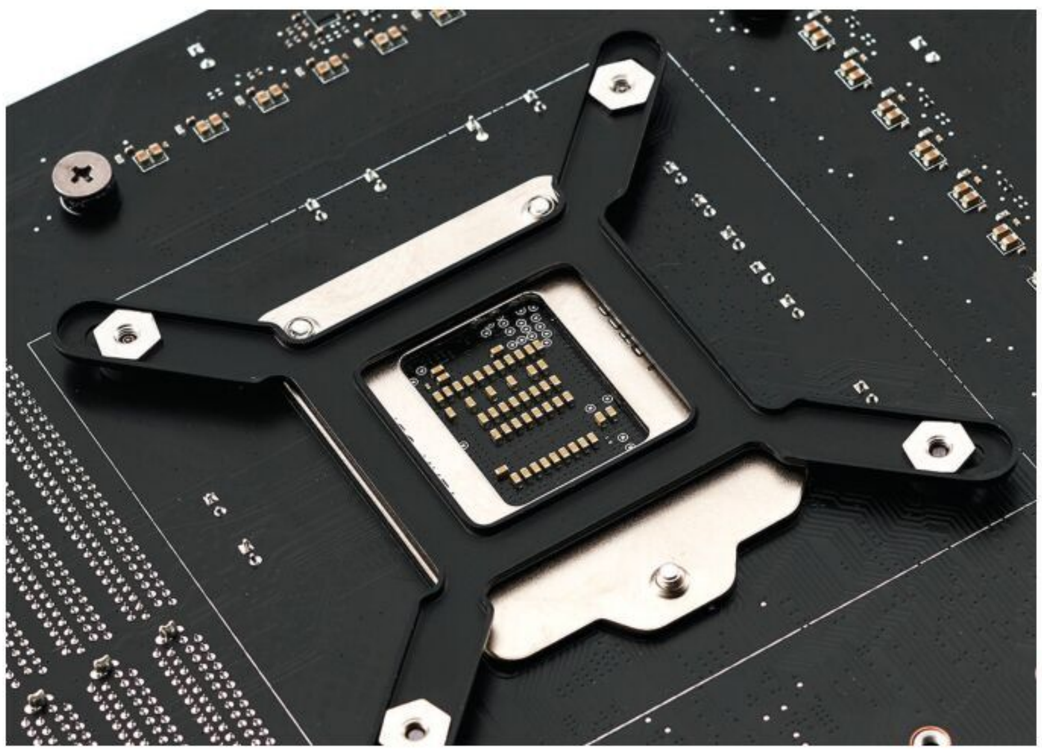
NZXT H510 ATX MID-TOWER CHASSIS

Cheap? Cheerful? Actually, the Nzxt H510 is one of the best budget chassis out there, and calling it anything else is insulting to this excellent low-cost case. ATX by design, this clean-looking mid-tower features a full-size PSU cover, intuitive cable bar, tempered glass side panel, and support for some decent cooling. It even comes with USB Type C support on the front I/O, and some awesome cable management solutions in the rear of the case, along with support for multiple 2.5-inch SSDs, and a hard drive bay for some 3.5-inch drives, too. It might not be as flashy as the H510 Elite, but then that's comes in at over twice the cost of this beauty for a very similar internal design. The only downside? Airflow isn't amazing, so over long periods of time, this machine could get a tad toasty. We recommend swapping out the two included case fans in the long term for something with a bit more grunt.
www.nzxt.com

Building the Rocket Lake

You can't go wrong with a white, black, and RGB colour scheme.

LENGTH OF TIME: 2-3 HOURS LEVEL OF DIFFICULTY: MEDIUM



01 FIX THE CPU COOLING BRACKET

An odd starting point, but regardless of what you're building, it needs to be secure. Thankfully, that's one thing our writer knew before starting. For this PC, we need to start on the back of our motherboard by screwing in the liquid cooler CPU mount. It can be tight inside the chassis, so be careful moving things around, take your time, and treat everything delicately. Lay the bracket on a table and gently align it with the four screw holes around the CPU slot. With the correct stand-off screws that come with the Corsair cooler, secure the bracket in place for later. With the back of the board prepped, we can turn our attention to the brain of the build: the CPU.

02 INSERT THE BRAIN

When handling Intel CPUs, it's important not to touch the bottom pins. Lightly pinch the sides when placing it in the motherboard. To begin, raise the retention arm. When looking at it straight on, you have to push this outward first to unhook it, then lift the arm to reveal the socket. Leave the plastic cover in place. Thankfully, on our Intel Core i9-11900K, one of the corners has an arrow that needs to align with a corresponding arrow on the mobo in order to position the CPU properly in the socket. This is the brain of the build, so take your time, don't apply any pressure, and it should all fall into place. Pull the retention arm down again slowly, so the bracket sits under the Torx screw, then push the arm back securely into the hook. Once done, the plastic cover pops off.

03 SSD STORAGE

What's a brain without memory? We're talking SSD, not RAM. We'll get to that shortly. Our 1TB M.2 Samsung SSD will store everything in this build. Luckily, the MSI motherboard is labeled. Find the cover that has "M.2" written on it, and unscrew it. With the top facing you and the contact points to the right, we need to slot the drive into the M.2 port first. At a 30-degree angle, slide the drive in, then rest the SSD cutout above the screw hole. Secure this with one of the tiny M.2 screws, and your SSD is in place. Now to cover and protect it. Beneath the cover is a thermal pad, perfect for heat dissipation. Peel the protective layer off and align the cover over the screw holes, then secure it on top. Our SSD is now in place, with its sunscreen on, and is ready to hold all the 1s

04 MOTHERBOARD MOUNTING

We have two sticks of RAM for this build, which means one thing: We can't just throw them in and hope for the best. There are specific slots that you need to use first if you are only using two. Look inside the motherboard's instruction manual to find out which slots you should use. For our build, it was the far-right and the second from left slots that we needed. Before placing the RAM in, make sure the clips on each end are opened. If not, push the edges of these down to open up the DIMM slots. Then take your DDR4 RAM sticks and look at the pins; you should notice an indentation along the bottom that determines how they fit. Align this indentation with the socket, and push it into place. A satisfying click tells you that your RAM is now snugly in place.

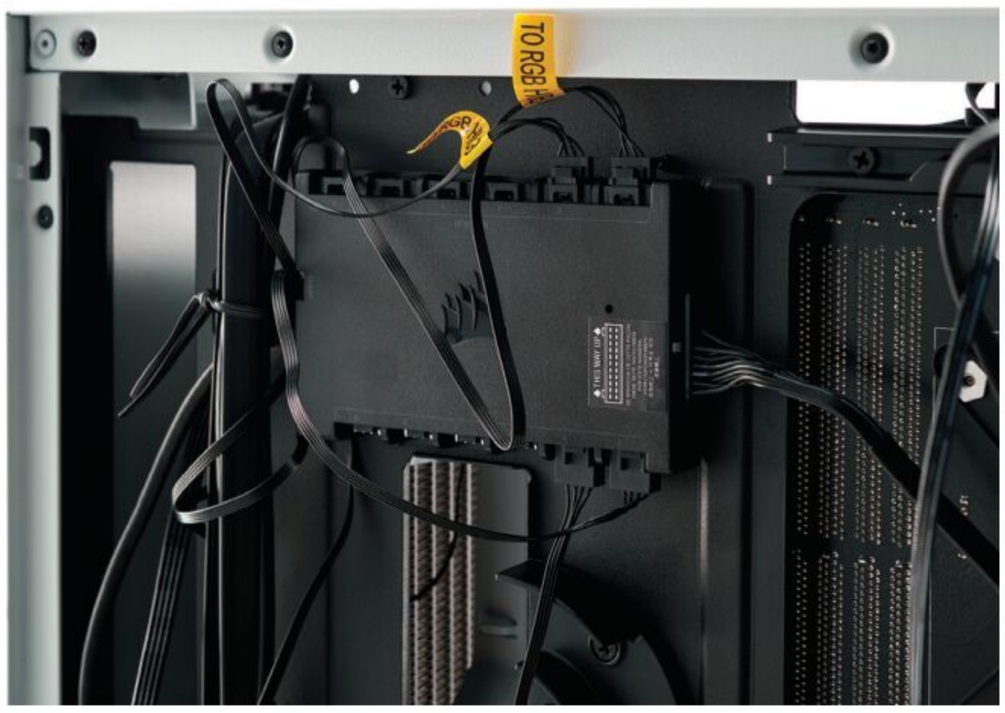
"The case doesn't have a front vent, just a side vent, so we won't be able to see them from the front. Remember, faces suck, so we need to keep the fan's faces pointing outward for effective air intake."

05 CPU PUMP AND MOTHERBOARD

Now we head back to the CPU and mounting bracket as we are about to install the first part of our CPU cooler. Our Corsair iCUE H100i Elite came with the correct Intel bracket attachment pre-installed on the pump. Attachments for AMD chips were also supplied. There was also a white replacement cover for the pump, so we swapped that over to match our case. The pump mount has a plastic cover we have to take off, with pre-applied thermal paste on the copper side. Align the screw holes and put the pump on top of the CPU, making sure the CPU pump hoses are coming out the correct side. These need to go toward where our fans will be. Slot the motherboard into the case with the pre-installed I/O shield on the board going in first. Now screw in the board.

06 KEEP IT COOL

Along with the exhaust fans that come with the Nzxt case, we have two Corsair fans for intake flow to attach to our radiator. The case doesn't have a front vent, just a side vent, so we won't be able to see them from the front. Remember, faces suck, so we need to keep the fan's faces pointing outward for effective air intake. The case comes with a bracket that goes between the radiator and the fans. With eight long screws and washers, this stage can be awkward, so we rested the radiator on top of the case and laid it down to make life easier. Make sure the radiator hoses are toward the top of the case, to ensure there's enough room for the behemoth GPU. Also, for cable management purposes, run all the cables to the back of the case for now, for installation later.



07 FAN CONTROL

Behind all the parts at the front, we have madness at the back. As we have just fed the cables from the fans to the rear, we can now connect them to the Corsair iCUE Commander Core. This is the fancy box that will control all our RGB fans. We stuck a 3M sticky-backed tab to an empty panel on the back of the PC, and connected up the fan, RGB, and CPU pump cables. The RGB cables are at the top of our Commander Core unit and the fan cables connect to the bottom. By routing them through the back, we ensure that the front looks tidy. While doing this, we also inserted the CPU pump cable into the CPU fan socket, as we didn't do this earlier. The last step here is to connect the Commander Core to the power supply. With this Core, you can add up to six fans with RGB support.

08 POWER SUPPLY CABLES

To avoid any mess at the front, we decided to insert the power supply cables into the motherboard first, then we routed them to the back. The first one we worked on was the big daddy: the ATX 24-pin. As the name suggests, there is a 24-pin connector on the motherboard to the right of the RAM slots. We slotted this in behind a panel to the right of the 24-pin connector – this cable splits into two, which we will insert into the power supply later. The next cable we have to deal with is the PCIe. Because this is for the GPU, we will rest this at the bottom of the case, ready to connect when the card is in place. To get power to the Commander Core, we need a SATA power cable; luckily, this can hide in the back of the case, so we stick this in and leave it toward the back.

"Behind all the parts at the front, we have madness at the back. As we have just fed the cables from the fans to the rear, we can now connect them to the Corsair iCUE Commander Core. This is the fancy box that will control all our RGB fans."

09 A HELPFUL TIP

You thought we forgot, but we didn't – the final power supply cable to connect to the motherboard is the CPU cable. Most are located in the top-left corner of the board, which is annoying. It's tight to bend a cable in the top and fit it around the back, especially as there is an exhaust fan pre-installed. With only four screws holding it in place on the top, removing this temporarily is a quicker and easier method than painfully trying to fit the cable through a cramped area. All the power supply cables have a clip on the connector so you can get it in the right way around and secure it in place. These are chunky cables, so be careful feeding them through, and be sure not to bend any pins on the motherboard.

10 POWER, POWER, AND POWER

All of these cables need to go somewhere from the motherboard: into the power supply. The basement of the case is a great place to store all of the cable madness. Out of sight, out of mind. Kind of, anyway; just make sure the cables are not caught or squashed, and you'll be just fine. The cables clip securely into the power supply in the matching ports. When this is all connected, it's time to screw the power supply into the chassis. With four screws at the rear, this is easily done. One important factor is to have the fan facing downward, because with the tall feet on this build, it should have good air circulation. Be careful not to have your rig sitting on a carpet; breathing isn't only important for us.

11 CASE CABLES

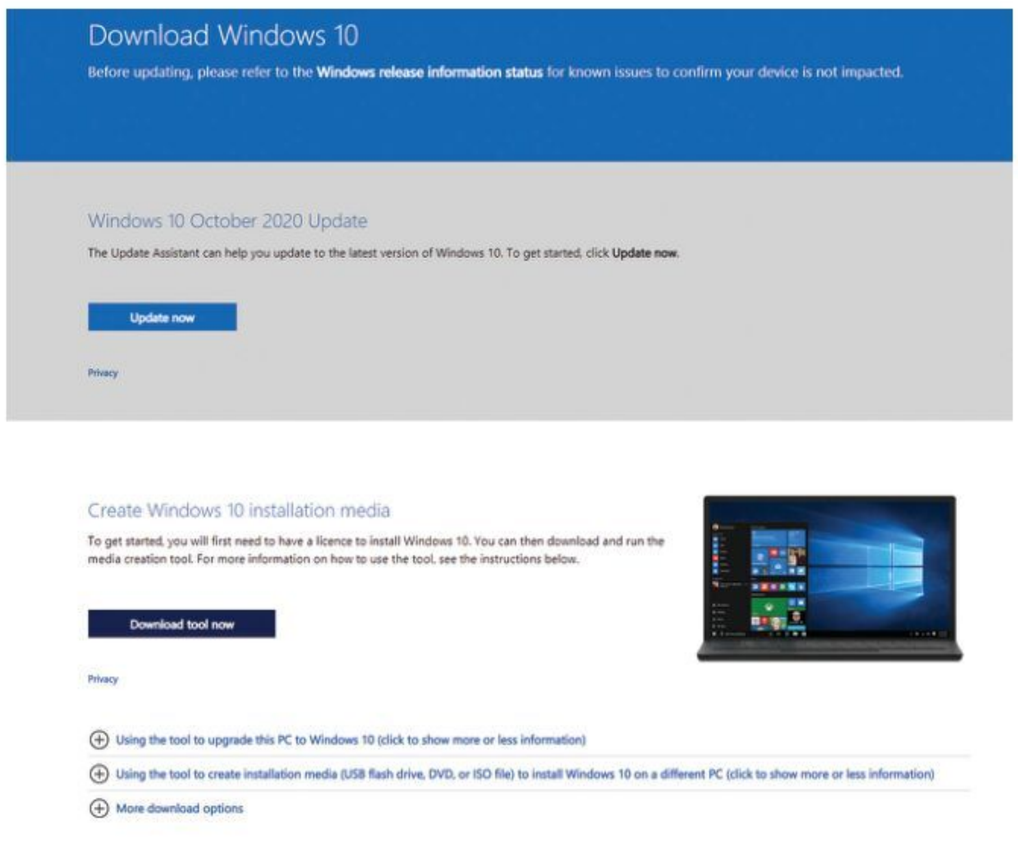
Before we fit the GPU and run out of room, we need to attach the remaining case cables to the board. First, take the exhaust fan cables to the back of the mobo for better cable management, and bring them in where the PWM connections are. We connected ours to the top-right of the mobo, in two system fan ports. These PWM connectors are delicate, so line them up, and connect them slowly. Following the Nzxt instructions, we inserted the rest of the cables for the front-panel switches. Check your motherboard manual to match up the header connectors.

12 GPU TIME

We've saved the best till last with this build: the graphics card. Seeing as the MSI RTX GeForce 3070 is pretty big, to say the least, it's the last chunk of metal to go into this case. Like the RAM, it can only go in one way. First, remove the two PCIe cover slots at the back of the case that align with the GPU PCIe slot. Pull the clamps down on the PCIe slot and click the graphics card into this port. Once in, screw it into the rear of the case. Next, attach the two eight-pin PCIe cables to the front of the GPU and run the cable out through the bottom and into the power supply. We don't have a fancy alternative PCIe cable here, unfortunately, and the provided cables tend to look a little messy.

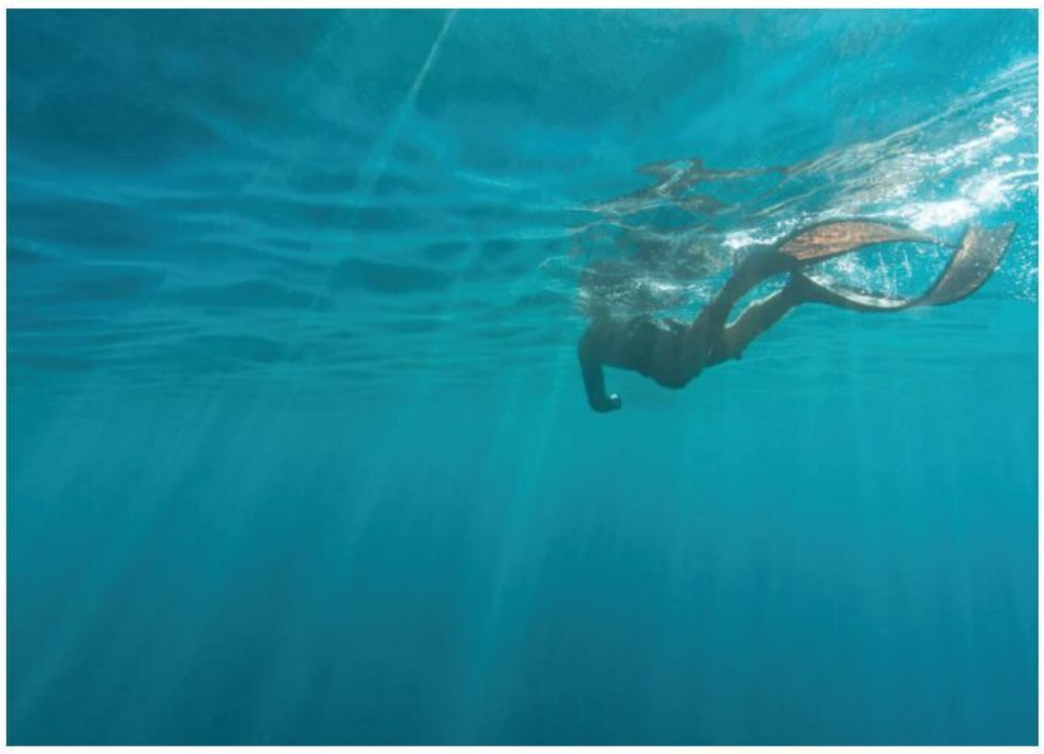
13 POP THE PANELS IN

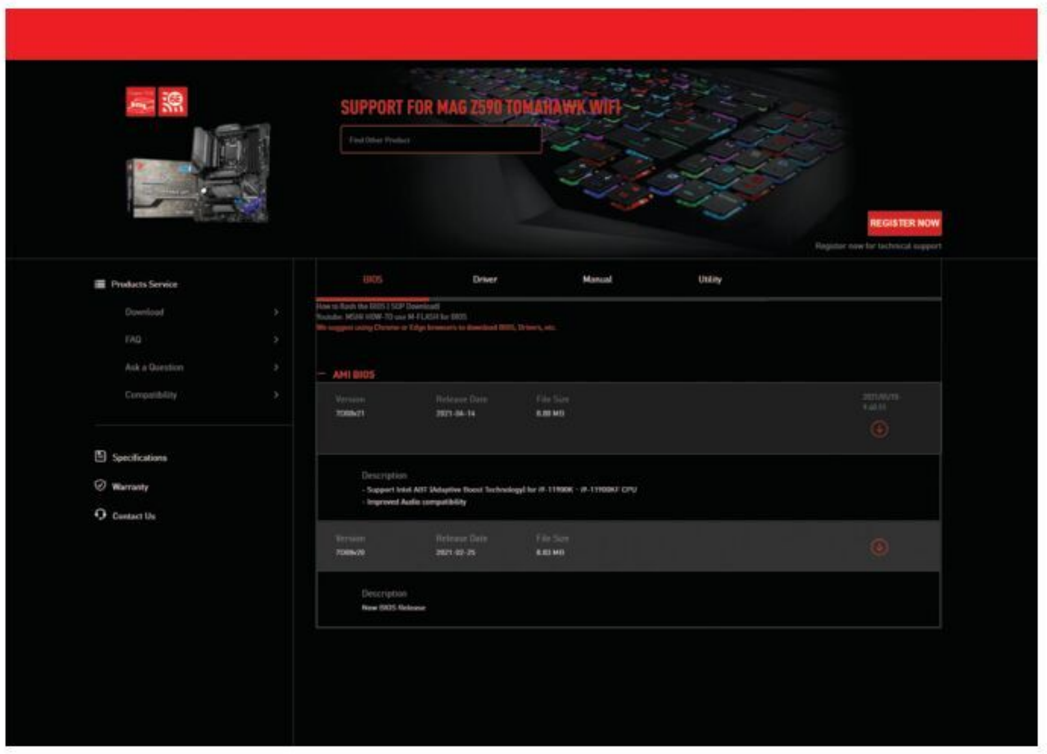
We're on the last stage now (physically, anyway). Take the solid side panel and slot it into place, securing it with thumbscrews. The same goes for the front tempered glass panel: Slot it in and tighten those screws. The case is done. The PCIe cable that came with our power supply isn't exactly pretty and is pressing up against the glass; something to look out for next time. Now everything is in place, it's time to boot up. With a sigh of relief, an explosion of RGB bursts into life inside the Nzxt case.



14 WINDOWS INSTALLATION MEDIA

Now we're on to a step that we all have to do with every new build. You need another PC at hand to open the software and a USB stick of at least 8GB. Head over to Microsoft's website and search for "Create Windows 10 installation media." Download this file, open up the software, and you will see a screen that says "Getting a few things ready." Accept the terms and conditions, and wait again. After the second time, it gives you the option to "Upgrade this PC now" or "Create installation media for another PC." Click the second option and proceed. On the next screen, leave things as default, and then you can choose which media to install Windows on to – click "USB flash drive," find your drive, and click "Next." It then starts to download.





15 GRAPHICAL GOODNESS

Once the Windows download has completed, take the USB drive and insert it into your new build. Boot up the PC, and then you're faced with the dreaded BIOS screen; fear not, because as scary as it was for our writer, this is an easy enough stage to complete. Every BIOS is different, unfortunately, but our MSI BIOS has the boot priority at the top. Arrange the order to make your USB drive the priority boot drive, then restart the PC. This should boot up the Windows installation and welcome screen for first-time use. Do as you please with these – it's up to you what you name your PC. If you haven't purchased a Windows key, don't worry, because you can do this later. After all of this, you should be welcomed by the default Windows 10 desktop.

16 UPDATING THE BIOS

We thought we were at the finish line but were rudely interrupted by a blue screen. We had the stop code "CLOCK_WATCHDOG_TIMEOUT." Updating Windows didn't solve the issue, so we decided to update the BIOS. Heading over to MSI's website, we found our mobo, went to "Support," and downloaded the latest BIOS. To install it, use the same USB stick with the Windows install on, download the BIOS file, and extract it to a folder on the stick called "BIOS." Insert it in a USB slot in the new build and restart that PC. Once booting, hit Delete until the BIOS loads. Press F7 and click "Use USB to flash BIOS M-FLASH." Accept and run it. The M-Flash screen should appear; click in the folder for the BIOS you created, and open it. Select "Yes" and leave it to do its thing. Sorted.

Clean and powerful?

Well, the white yacht has certainly traveled across some rough waters to finish its voyage – it wasn't exactly plain sailing sorry folks, our puns are getting out of control. We all know first builds are awkward but we got there in the end. With patience and a level head, this build was successfully completed. As far as looks go, it sits in the classic stormtrooper monochrome design category, but that isn't a negative. These colours are timeless, especially when sitting in the pretty yet affordable Nzxt H510 case. And this PC runs as well as it looks. Any RGB colour complements this look, and for the price, you cannot go wrong with the case. The actual installation was simple enough; the only hiccups on the journey were due to the fact that this was a first-timer's build. If you've managed to build a PC with no issues at all, we tip our hat to you.

Cables were a little tight in the case toward the top and bottom, forcing us to remove the top exhaust fan at one point to gain more access to the CPU port. Other than that, the case has great cable management routes and Velcro to keep everything neat and tidy. This helps a lot when building, because a busy, tangled mess can easily overwhelm a newbie.

A few tips for beginners: Keep everything neatly organised when building, have a designated place for each part, and keep things spaced out. Make sure you box everything up once you are done, to keep parts out of your way. Also, work on a large table with a screwdriver to hand at all times, and use a little dish to keep your screws together. For a beginner, this mid-tower ATX case is great to work with on the whole, and a good place to start when it comes to jumping into custom PC life.

Benchmarking

It was great to incorporate Intel's leading CPU into this build. The Intel Core i9-11900K only gave us a minor problem when it came to the BIOS. Luckily, while researching the stop code that it was giving us and looking into any potential BIOS issues, we found that MSI had released an update regarding this processor. It now supports Intel ABT (Adaptive Boost Technology) for i9-11900K to i9-11900KF CPUs. Perfect, right? This solved our issue and we were able to benchmark the PC properly. Paired with a more-than-capable RTX 3070 from MSI that we were lucky enough to get our hands on, this makes for a mean machine. With both of these sitting on our MAG Z590 motherboard, it should provide decent longevity. The board is a big part of the Rocket Lake appeal and worth the large price tag. We benchmarked this against the previous next-gen Intel build from 2020. That Intel Core i9-10900K build performed well based on rendering.

To start with, this i9-11900K build beats the i9-10900K rig in gaming pretty significantly. We achieved just over 100fps on *Rise of the Tomb Raider*,

"A few tips for beginners: Keep everything neatly organised when building, have a designated place for each part, and keep things spaced out. Make sure you box everything up once you are done, to keep parts out of your way."

01 If we did this build again, we would swap the fans and the radiator around, so that we could actually see the fans in the PC.

02 Unfortunately, our GPU bracket isn't compatible with our setup, hence why it looks like a skate ramp.

03 We changed out Corsair's black CPU pump cover for the white one provided in the box, for consistency.

04 wo more sticks of RAM could have improved this build's look and performance….

whereas on the older build we managed 69fps, which isn't bad, but it's a great result for this cheaper PC. With *Total War: Warhammer II*, we gained an extra 10fps over the older PC, so again this is a positive for the latest chip. It also wins on the 3DMark: Fire Strike benchmark, with a performance increase of 15 percent. Sure, our MSI GeForce RTX 3070 8GB Gaming X TRIO plays a role in this, but with the RRP in mind, it's a big difference.

Where the rendering machine reels some points back in is with the CrystalDisk read and write tests, and the Fryrender benchmark. Saying that, the results were not too far off at all – with a PC that can render nearly as well but can game a lot better, our build seems like a good path to go down. In Cinebench R15, the multicore index score was down by seven percent compared to the rendering PC, but it beats it on the single-core index by 12 percent.

Final points

Both machines are more than capable for a multitude of purposes, but we are glad to see how well our new mid-tower yacht looks and performs. With gaming coming in comfortably over the 60fps target and decent rendering speeds, too, it seems like a great all-arounder. This PC also sails along quietly, which is always an added benefit. To improve the build, two more sticks of the Corsair Vengeance RGB Pro SL DDR4-3600 RAM would be nice. Also, if we could have replaced the stock exhaust fans with the same Corsair ones we have up front, that would have helped with aesthetic consistency. Overall, for a first build, it was challenging, but it proves that you shouldn't be afraid of starting custom PC builds – this new kid on the block certainly had an enjoyable experience. ■

APC LABS BENCHMARKS

Indicates best result

	CINEBENCH R15 SINGLE	CINEBENCH R15 MULTI	FRYRENDER	CRYSTALDISK SEQUENTIAL READ	CRYSTALDISK SEQUENTIAL WRITE (MB/S)	3DMARK: FIRE STRIKE	RISE OF THE TOMB RAIDER	TOTAL WAR: WARHAMMER II
	Index	Index	M:S	MB/s	MB/s	Index	FPS	FPS
Rocket Lake	251	2,413	01:32	2,721	2,769	26,706	103	75
Zero-point	225	2,590	01:16	3,352	2,961	23,159	69	65

Our zero-point consists of an Intel Core 10900K, 32GB (4x 8GB) Corsair Dominator Platinum RGB White @ 3600, a Zotac Gaming GeForce RTX 2080 Super AMP Extreme, and a 1TB Corsair Force MP510 M.2 PCIe 3.0 SSD. All game tests were performed at 3440x1440 on ultra.

HOW-TO

TOP TIPS TO TACKLE TECH TROUBLES

QUICK TIPS

APC experts solve computing problems

The *APC* team tackle problems across the spectrum of devices and software. Learn a new trick or fix you can use.

PC won't stay off

I've built around 30 PCs over the past 20 years but have never seen this before. I recently built a new PC with Windows 10 Pro and all updates installed. My build: Gigabyte x570 PRO WIFI, Ryzen 5 5600X, 32GB RAM, 2TB MP600 NVMe SSD, RTX 3070 graphics, and EVGA BR600W PSU.

If I click "Start > Power > Shut down," the computer simply restarts. I've searched online, tried everything in Windows, including turning Fast Boot off, but nothing works. The only way to switch off my PC is to hold the power button for a few seconds for a forced shutdown. Obviously, I'd really like to resolve this problem and be able to do a Windows shutdown the normal way.

Any help would be great.

JOEL BRIERE

APC responds: Joel had already anticipated our first suggestion – making sure the automatic restart option is disabled when Windows blue-screens – so we next asked him to check Event Viewer for any potential clues. To open it, type "event" into the Search bar and click "Event Viewer." After a short pause, you'll get a summary of events by type, including Critical, Error, and Warning. Again, Joel reported no errors relating to reboots could be found.

At this point, we decided to run with the idea that Windows might not be the problem, but that the hardware was somehow involved. We widened our search to see if other X570 boards were exhibiting similar symptoms, and discovered a combination of Windows and UEFI settings that fixed Joel's problem. Simply put, by re-enabling Fast Boot in Windows, but disabling Fast Boot and Wake on LAN in the UEFI, Joel was able to get his PC to shut down properly at last.

CPU not supported

Recently, program updates have failed with the error "CPU is not supported." Ten years ago, I cobbled together a DIY system based on a quad-core Intel Core i7-875K (2.93GHz) on an Asus P7P55 LX motherboard. 8GB RAM and an AMD Radeon HD 5800 series graphics card rounded it out, and over the years a 500GB SSD, 5TB hard drive, and a replacement fan or two have maintained the system performance through clean installs of Windows 7, 8, and 10 Pro.

Now the CPU support issue is preventing updates to VMware, some Zoom add-ins, and my go-to movie creation/editing application. The question is, can I get by with just a CPU update, or is a new mobo needed?

ALAN KEYWORTH

APC responds: It looks as if your CPU has come to the end of the road, and likely the rest of your system too – at least for these specific apps. You might be able to "trick" VMware into bypassing the CPU check during the upgrade process using an "allowLegacyCPU =true" flag (see **https://bit.ly/3y0ENv6** for full details and why it's not a long-term solution).

The age of your system means a simple CPU upgrade won't cut it – it's time to bite the bullet and look for a new system, basically a motherboard, CPU, and RAM. You can, of course, source these separately, but in 2021 even a budget system will outperform your formerly state-of-the-art rig. The Core i7-875K scores 3,127 on Passmark's CPU benchmark – the mid-range Core i5-10400 has six cores (12 threads) and scores 12,436 in comparison. If you can afford better, use Google to perform some comparative benchmark searches along the lines of "i5-10400 versus i7-875K" to see what's out there based on your budget.

Black screen in Zoom

As a music teacher, I spend a lot of time on Zoom and sometimes I need to share my screen. Problem is it doesn't always work. When it doesn't, the students I'm working with see a black screen that only displays my cursor, which they can see move. Also, if I open menus while sharing, that can be seen too as a change in texture. One day I got a black screen when trying to share my AOL desktop, but it worked fine when I switched to sharing Sibelius. My specs are: AMD FX 9590 CPU, Gigabyte 90FXA-UD3 mobo, 16GB of DDR3 RAM, and an AMD Radeon R9 200 with a Sept 22, 2020 driver running Windows 10. My version of Zoom is up to date. Any help would be appreciated.

ALAN FRANCIS

APC responds: We jumped through various hoops trying to help Alan fix his problem. There are many potential causes – for example, if your desktop resolution is greater than regular HD (1920x1080), trying to share the desktop can result in a black screen with a cursor, a problem that appears to be hit and miss depending on the application you're planning to share. The only solution currently on offer is to reduce the size of your desktop to 1920x1080 for sharing purposes.

Some users have reported similar problems when running Chrome in the background during Zoom meetings – switching to Edge resolved the problem in their case, so it's worth trying that, too.

Another cause of black screens while sharing is if you have both integrated graphics and a graphics

"The only way to switch off my PC is to hold the power button for a few seconds for a forced shutdown. Obviously, I'd really like to resolve this problem and be able to do a Windows shutdown the normal way."

card set up with automatic switching between the two – in this rare case, you need to configure Zoom to default to the integrated graphics chip to eliminate the problem. For example, Nvidia users should visit "Manage 3D Settings," switch to the "Program Settings" tab, then click "Add" to add Cpthost.exe from C:\Users\YOURUSERNAME\AppData\Roaming\Zoom\bin). Once added, set "Preferred Graphics Processor" to "Integrated graphics," and click "Apply" to hopefully fix it.

Unfortunately, none of these solutions helped Alan, but we subsequently discovered that his broadband Internet connection has a maximum upload speed of just 2Mb/s, which puts him on the borderline when it comes to video conferencing. The screen-sharing demands themselves aren't too onerous – no more than 150kb/s with video thumbnail, but once you start adding in additional demands (1080p video requires 3.8Mb/s, for example), it's possible that issues with the line, a weak Wi-Fi signal, or bandwidth being shared with other internet-connected devices in his household could cause the intermittent problems he's suffering.

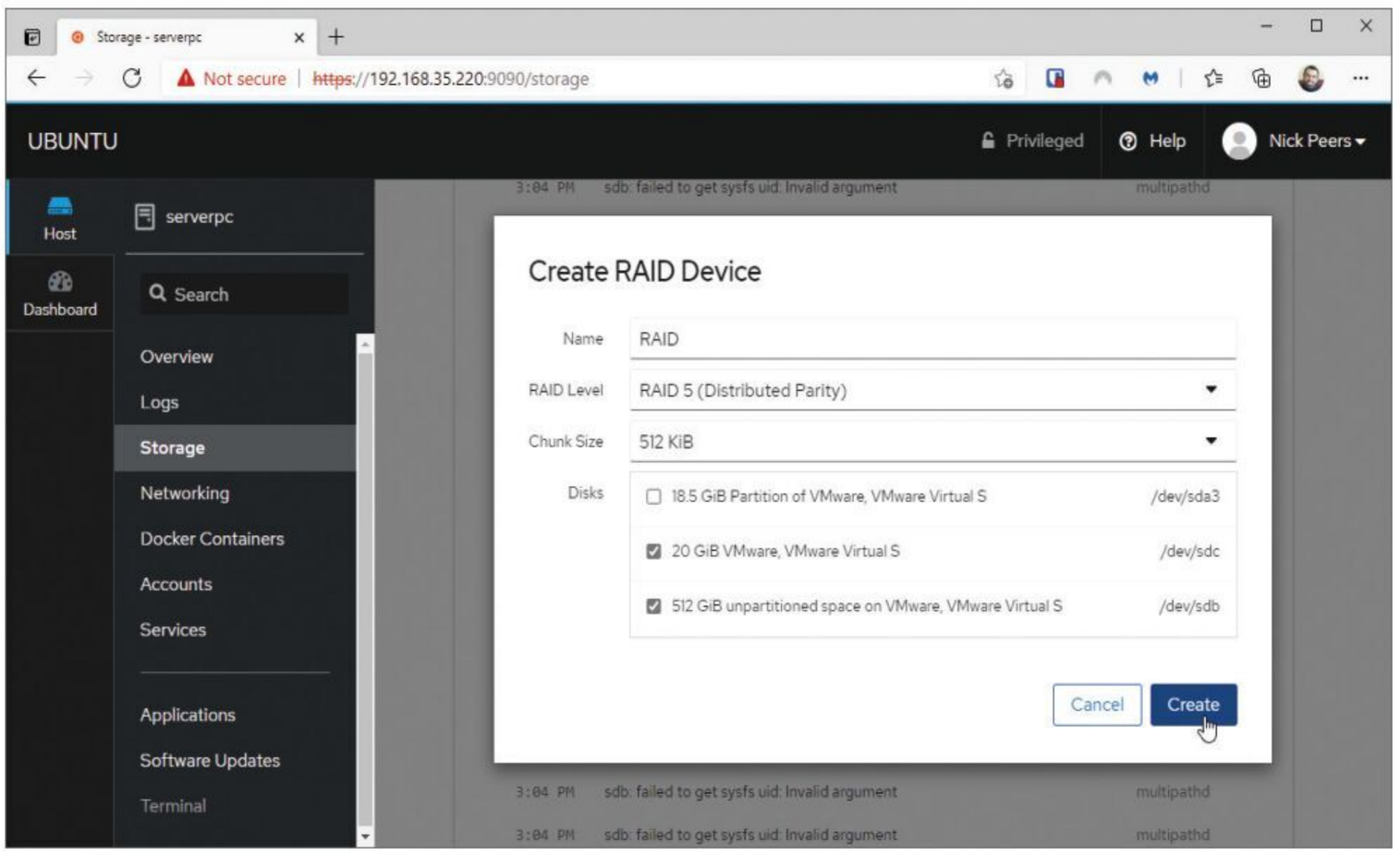
NAS RAID query

In the April 2021 edition, I tried to follow the instructions to set up the Ubuntu NAS server. I got stuck on "Set Up Folder Sharing." When I tried to create the folder using the command "mkdir ~/media/bay1/shared" I got an error: "Cannot create directory shared: Permission denied." I did some searching and found that for a new ext4 filesystem, you need to change the permissions so your user can access it and read/write to it:

```
$ sudo chown -R $USER:$USER ~/media/bay1
```

(Where "~/media/bay1" is the path to where the drive is mounted.) This solved my problem. What steps were left out in the instructions that were in APC? Also, would it be possible to give the steps necessary to configure a RAID 5 array?
LEON GARFIELD

APC responds: Thanks for sharing the tip, Leon. It seems you may have discovered something we skipped over in the original article



You can set up a RAID array in Cockpit.

– namely that the mount point inherits the permissions of the device it's attached to, which are set to root by default. Your fix will be welcome to those who suffered the same fate as you when trying to use any newly mounted drives, and we apologise for the omission. Blasted Linux permissions.

You can configure RAID 5 drives directly from Cockpit, but remember the drives you plan to use must be empty (i.e., unpartitioned). Navigate to the "Storage" section, click the blue button next to "Devices" in the top right-hand corner (or scroll down if it's not visible), and choose "Create RAID Device."

You'll see "RAID 5 (Distributed Parity)" is selected by default, and that all your drives are listed. You should be able to identify each by their size and their device address (dev/sda, dev/sdb, and so on). Simply select those drives you wish to include in your array, give them a suitably descriptive name, and click "Create." If you come across any error messages, you may have selected the wrong drives, or you may need to check the drives haven't been previously initialised before trying again.

Once the RAID array has been set up, administer it directly from the" Devices" menu, where you'll be able to create a partition table before partitioning and formatting it in the usual manner. Remember the size of the partition will be restricted to the size of the smallest drive you've added to the RAID array.

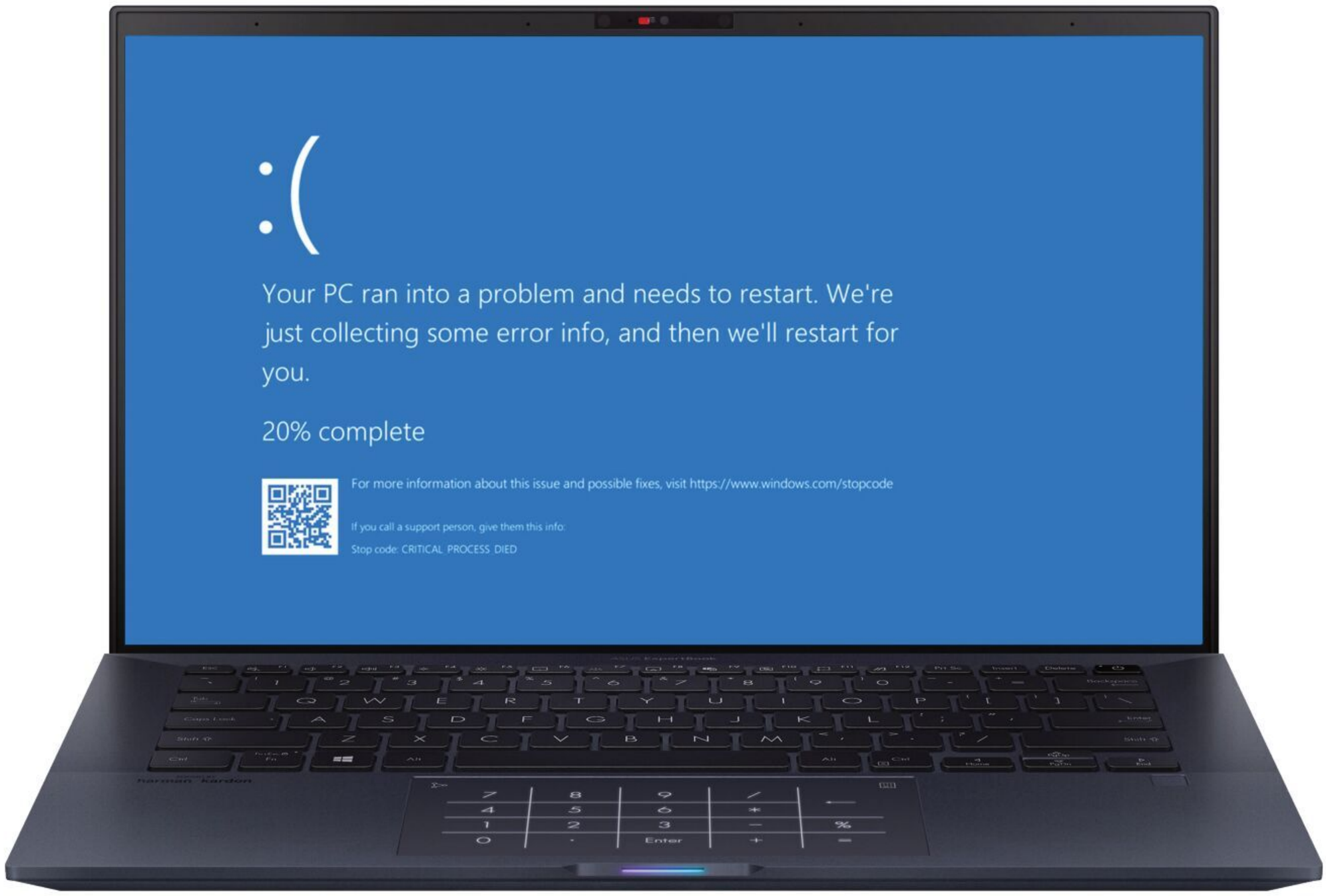
Time to reinstall

I have a four-year-old Dell desktop running Windows 10 Pro version 20H2, build 19042.685. I've been experiencing a variety of minor problems but lately things have gotten to point where I feel a full, clean install of Windows is warranted. I'm unable to download updates (error 0x800f984) because I'm supposedly missing several key files. The computer will boot to Windows, but randomly shuts down from time to time. No single event triggers this – it's a hard reboot.

I've run the Windows Update Troubleshooter. It claims to find problems and fix them, but it doesn't. I've tried running SFC and DISM from the command prompt – no fix. I'm out of ideas. Can you help?
RW SCOLARI

APC responds: We sympathise, but you've answered your own question. Time for a complete clear-out and restart from scratch. First, take the usual full set of backups, including a complete drive image of your current setup. Why? Because if the reinstall doesn't fix anything, you can quickly roll back. Once done, perform a full reinstall. Avoid the reset or recovery options and use the Media Creation Tool (**www.microsoft.com/software-download/windows10**) to create bootable media you can boot from, formatting your boot drive to ensure it's a completely clean install.

If the problems reappear, then it's probable that an underlying hardware problem could be to blame. ■



WINDOWS

How to fix a Windows Blue Screen of Death (BSOD)

Find out why you got a BSOD and how to stop it.

Few things are more frustrating. You're in the middle of working on a project, reaching a major milestone in a game or maybe just booting up your Windows 10 computer and, just like that, the entire OS crashes and presents you with a Blue Screen of Death, usually for no immediately apparent reason.

In Windows-speak, the term "Blue Screen of Death" is usually abbreviated as BSOD. It describes an error of some kind that hits the operating system hard enough that it's forced to quit. Microsoft itself labels such errors with "stopcodes." Thus these errors may also be generically named "stop errors." There's an example that shows what a BSOD sometimes looks like above.

Understanding the BSOD screen

The screen starts with an old-fashioned unhappy face emoticon " :(" (a colon, followed by an open parenthesis). Next, you see a brief explanation that "Your PC ran into a problem and needs to restart." Windows writes one or more log files when a stop error occurs, so you see language about "collecting some error info" and a counter that keeps track while it's writing that data (shows as "20% complete) above.

Microsoft provides a scannable QR code in modern BSODs (lower left) that you can scan with a smartphone and look up that way. The message also provides a lookup URL for stopcodes, where you can enter a numeric stopcode (and where you'll see most common stopcodes, including the one shown above). The most common stop codes include:

- CRITICAL_PROCESS_DIED
- SYSTEM_THREAD_EXCEPTION_NOT_HANDLED
- IRQL_NOT_LESS_OR_EQUAL
- VIDEO_TDR_TIMEOUT_DETECTED
- PAGE_FAULT_IN_NONPAGED_AREA
- SYSTEM_SERVICE_EXCEPTION
- DPC_WATCHDOG_VIOLATION

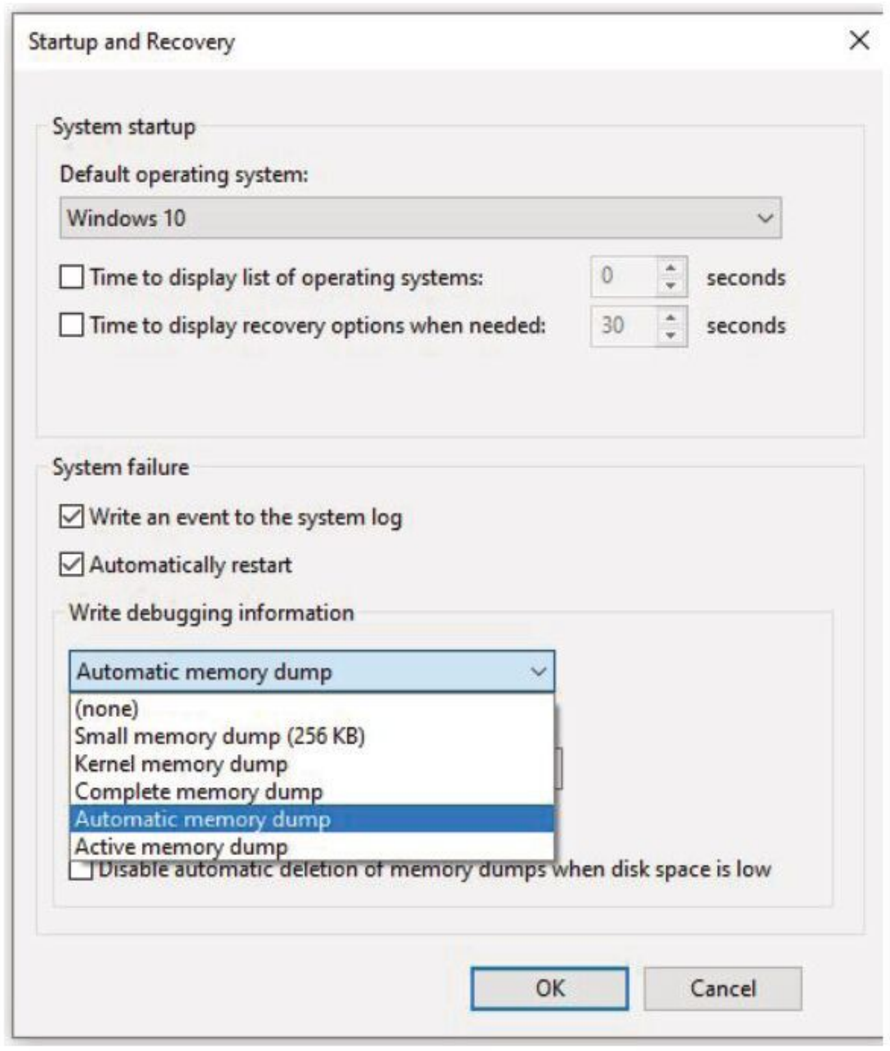
You can also download the Microsoft Error Lookup Tool (current version: Err_6.4.5.exe) to look up numeric error codes at a command prompt or in PowerShell, if you prefer.

In Windows 10, BSODs aren't always blue

Before Windows 8 came along in October 2012, BSODs always appeared on dark blue screens. These were chock-full of text and instructions, and were hard to follow. With Windows 8, Microsoft switched to a kinder, gentler format. They also whittled down the information that appears on screen. In fact, the background colour in Windows 10 is sometimes green, which is why you may see some of them called GSODs ("Green Screens of Death").

Making sense of BSOD data

Though nobody wants to see a BSOD on a Windows PC, they do occur from time to time. In



Crash dumps come in various forms with associated typical sizes.

"BSOD describes an error of some kind that hits the operating system hard enough that it's forced to quit. Microsoft itself labels such errors with stopcodes."

the vast majority of cases, the PC will restart itself automatically after an error log, called a crash dump or a dump file (extension .dmp) is created. By default, Windows 10 stores dump files in one of two locations.

You can manage crash dumps through Advanced System Settings in Windows 10 (type "Advanced System Settings" into the search box, then click "Settings" in the Startup and Recovery pane). You can also choose to toggle "Automatic restart" to off here, if you would prefer that any future BSODs stay on the screen until you get a chance to see them and write down (or take pic of) any relevant data.

If you select "Small memory dump" as the option for saving crash dumps, such files show up as Minidump.dmp files. For all other selections, the crash dump is named Memory.dmp. Crash dumps get written to the %SystemRoot% folder, which usually expands to C:\Windows. By design, small memory dump files are limited to 256KB in size. Other memory dumps will vary in size up to the size of memory on the PC where the dump is collected. Thus, on a PC with 16 GB of RAM, a Complete memory dump file will always be 16 GB in size (and other dump files, except for the small memory dumps, can be as large as 16 GB, but will often be smaller).

Examining a crash dump file can be helpful when trouble-shooting related causes. That said, many users simply search on the stopcode and/or the numeric error code when seeking remediation advice. (Note that Microsoft calls that numeric code a "bug check code" or "bug check string."

What to do when troubleshooting a BSOD

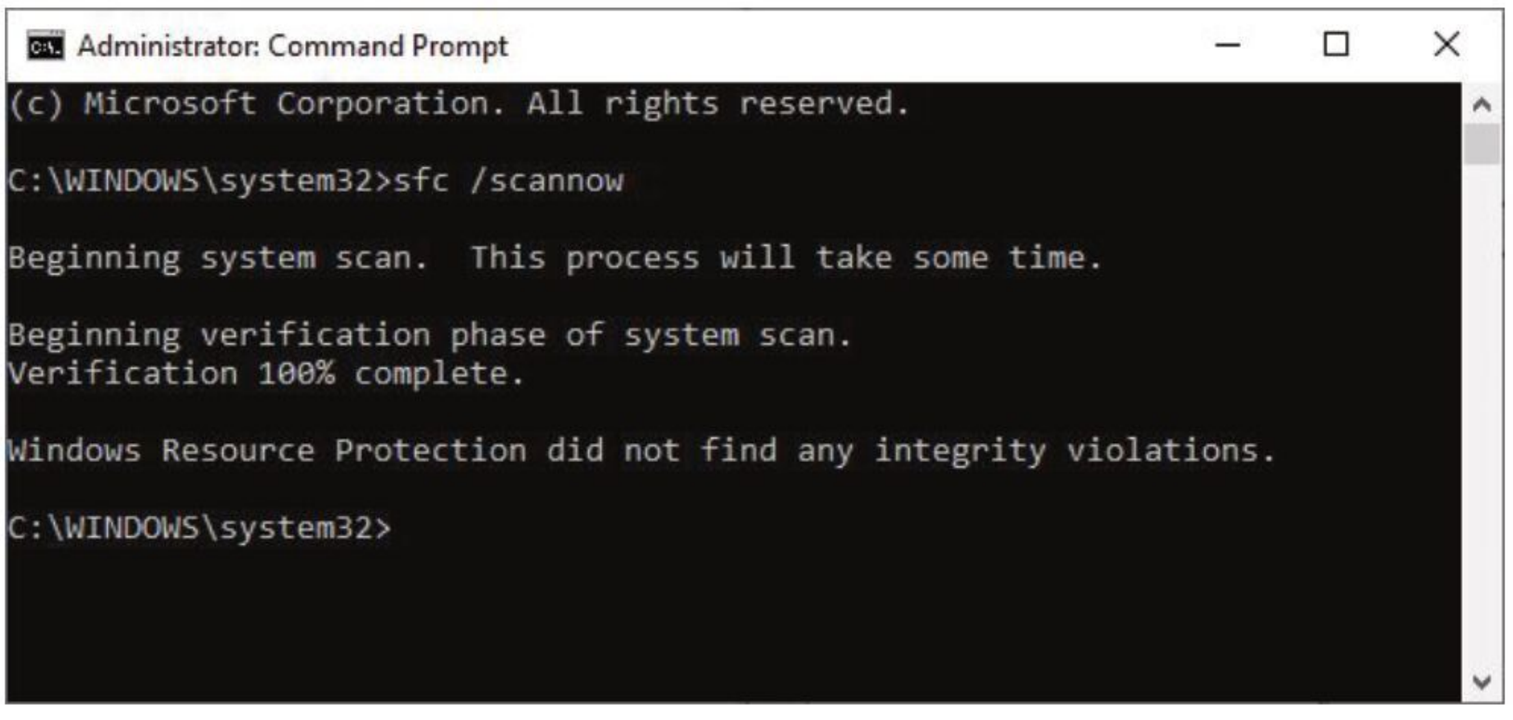
The immediate tendency following a BSOD is to get right into fix-it mode, start looking things up, and attempting repairs. Not so fast! Microsoft explains the entire troubleshooting process in its "Troubleshoot blue screen errors" tutorial. While you can – and probably should – read the Microsoft advice in its entirety, here's a summary of key recommendations:

1. Shut down the Windows PC that experienced the BSOD
2. Disconnect all USB-attached devices except for mouse and keyboard (or wireless dongles).
3. Reboot your system into safe mode from the Windows Recovery Environment (WinRE)
4. If you recently installed new software, uninstall that software.
5. If you recently installed a new device driver (or your BSOD info points to a driver or device), uninstall or roll back that driver (if you don't really need the device you can disable it temporarily instead)
6. Restart the PC, and see if the BSOD recurs. If not, you've probably isolated the cause and can start researching some kind of fix.
7. If the BSOD recurs despite the items taken out of the picture by removing, disabling or uninstalling them, whatever's still left in the picture remains problematic. At this point you want to reboot into safe mode once again, and open an administrative command prompt or PowerShell session. From the command line, enter these commands, one at a time:
   1. DISM /Online /Cleanup-image /Restorehealth
   2. SFC /scannow

   The first of these two commands finds and replaces any damaged operating system components in the side-by-side filestore (aka WinSxS). The second of these commands runs the System File Checker (SFC) and will repair any damaged files it finds.

   Note that if SFC finds and fixes anything, you should run the command until it comes back with a clean bill of health (in some cases, I've had to run it two or three times before it came back clean). Note further that running either or both of these commands can take some time to complete, especially if one or both find items in need of fixing. ■

Keep running SFC until it's cleaned up all integrity violations.



MAC

Save web pages for later

Curate your own reading list using Safari in macOS Big Sur.

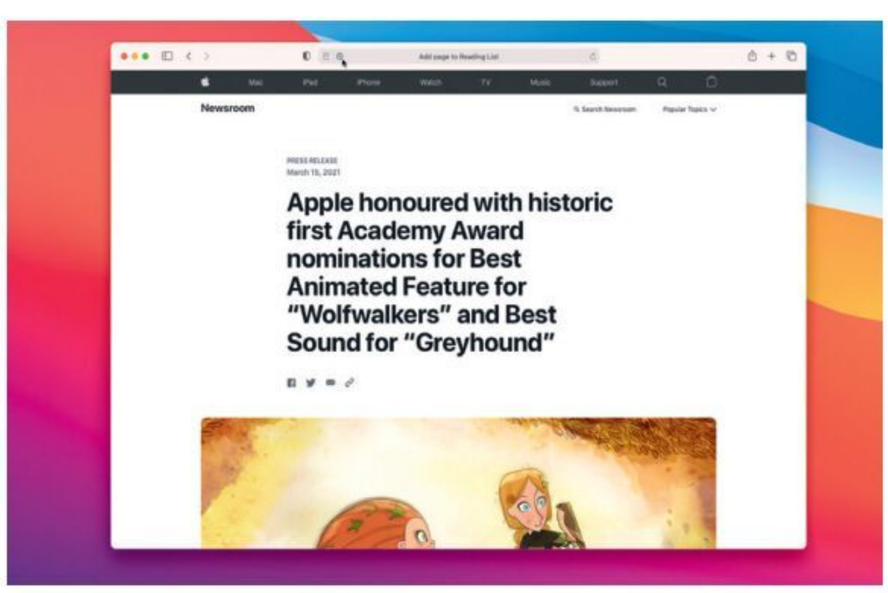
IT WILL TAKE
10 minutes
YOU WILL LEARN
How to save web pages so you can read them at a more convenient time
YOU'LL NEED
Safari, macOS 11 or later; Pocket and Instapaper optional

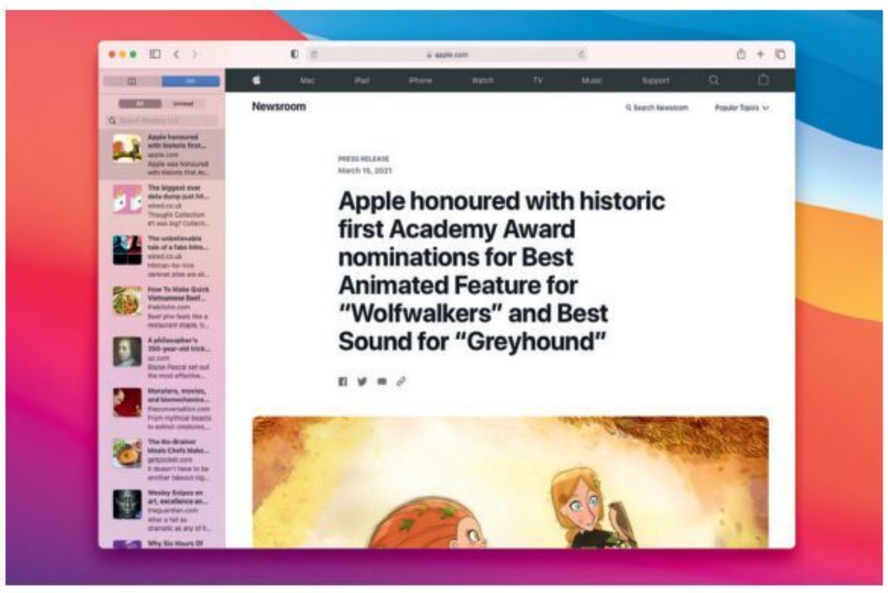
Apple's macOS Big Sur offers plenty of ways to save interesting content for later. For example, you can highlight text on a web page and drag it to a document, which can then be saved to read anywhere. That is fine, but Safari offers better options.

Many of these methods are built right into the browser. Reading List lets you save any article to a library for later reading. By default, your saved articles require an internet connection to view, but you can save them for offline consumption. Safari extensions like Pocket and Instapaper (both free) offer extra features over Safari's Reading List. For instance, Pocket lets you see what other people have saved and follow interesting curators. Instapaper, meanwhile, lets you tweak things like fonts and colours to make reading easier and more comfortable.

To learn how to use Reading List and combine it with Safari extensions for a top-notch content collection, read on.
ALEX BLAKE

HOW TO Start and manage a reading list



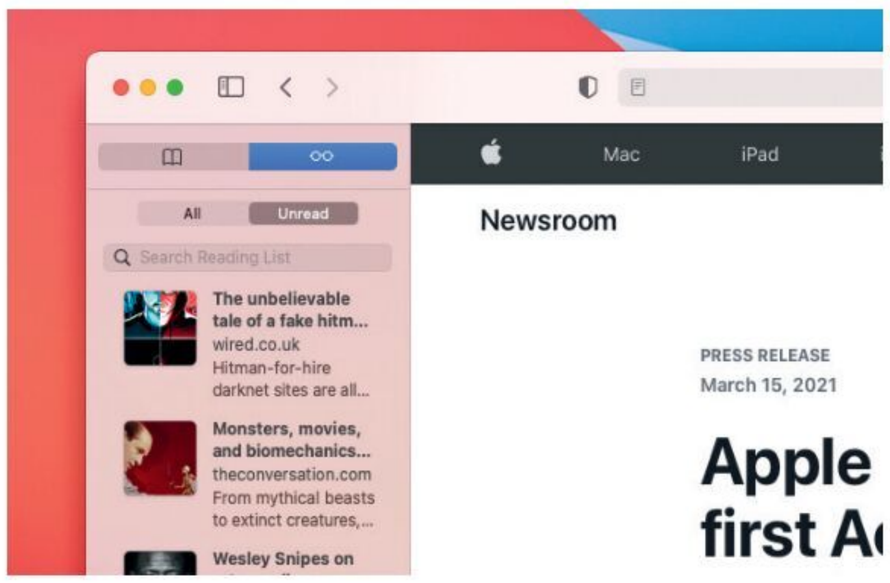


01 NOTIFICATION CENTRE BASICS

When a notification appears, swipe right on it to hide it. Click the time and date in the top-right corner to open Notification Centre. Here you can act on your alerts, including seeing more details, closing them, and more.

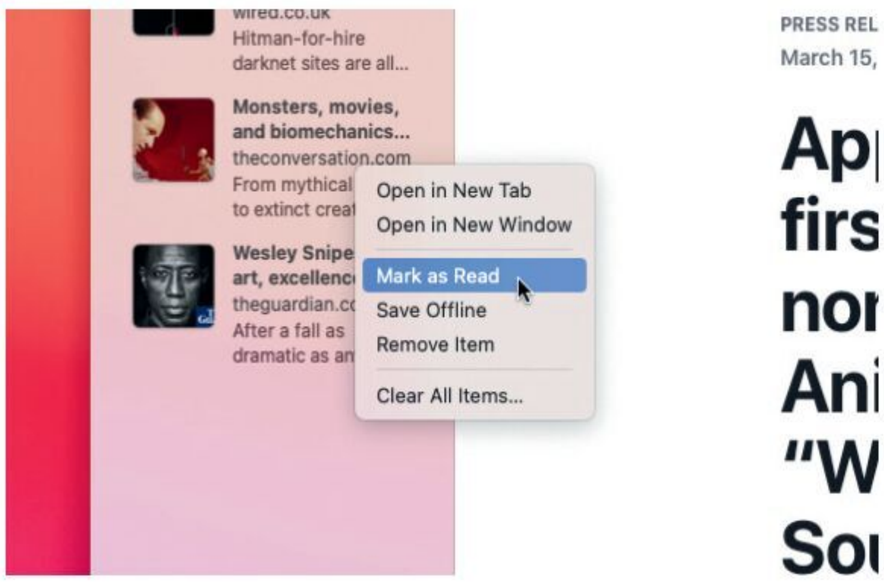
02 STACKED ALERTS

Multiple notifications from the same app are grouped in stacks. Click the top notification in a stack to expand it and see the others, or hide them by clicking Show Less. Clear (or Clear All) removes the stacked alerts.



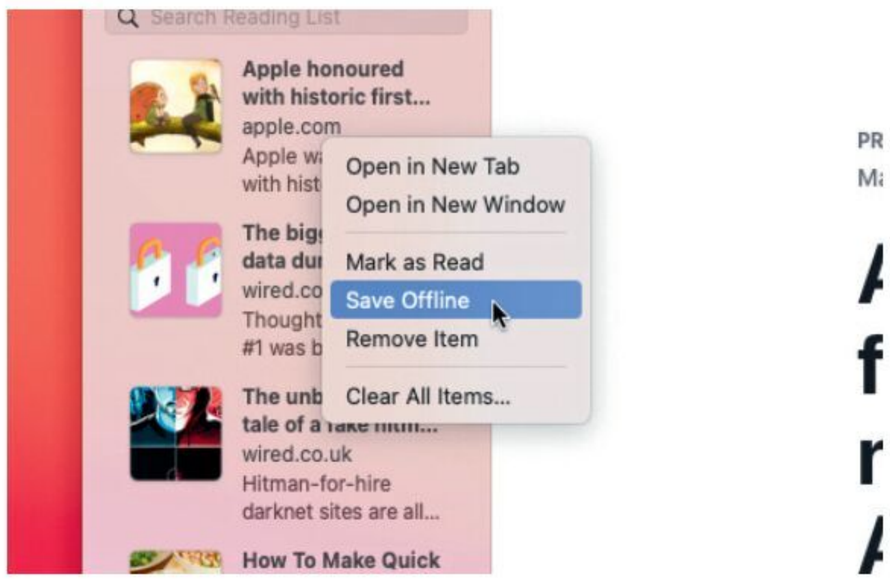
03 FILTER SAVED PAGES

In the Reading List sidebar, scroll upwards, then click the buttons that appear at the top to filter between all saved articles and just those you have not read. You can also search through your saved articles here.



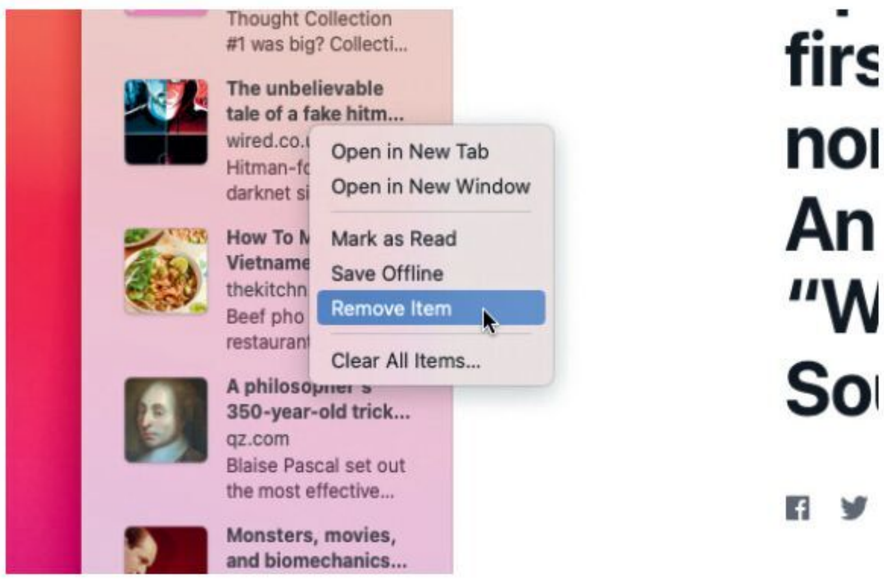
04 READ OR UNREAD?

You can mark a page as read or unread regardless of whether you have actually read it. In the Reading List sidebar on the left, control-click a saved page, then click Mark as Read or Mark as Unread to change its status.



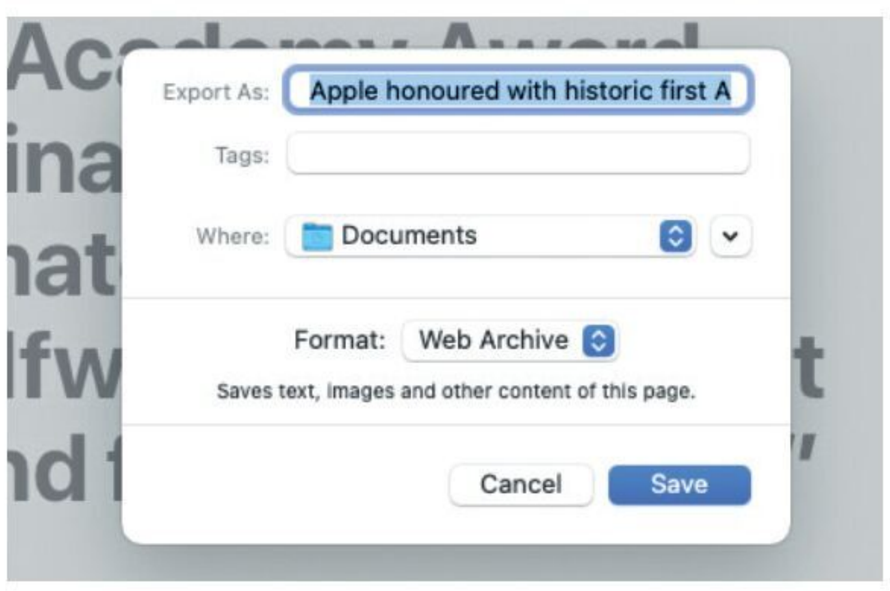
05 SAVE OFFLINE

If you are going to be travelling without an internet connection – or just prefer to read things offline – you can save a page straight to your Mac by control-clicking it in the Reading List, then clicking Save Offline.



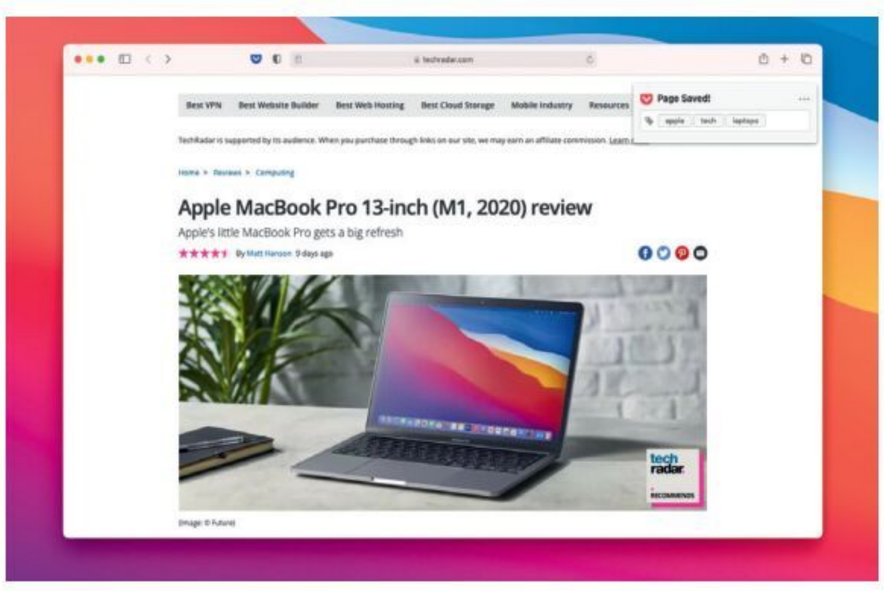
06 REMOVE PAGES

Finished reading a saved page in your Reading List? You can remove it by control-clicking the page summary in the sidebar, then clicking Remove Item. Alternatively, click Clear All Items > Clear to remove everything.



07 SAVE AS WEB ARCHIVE

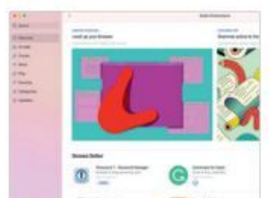
You can also export a page as a web archive, which saves text, images, and links. This is useful for saving receipts, for instance. Click File > Save As, then select Web Archive in the Format drop-down and click Save.



08 TRY POCKET

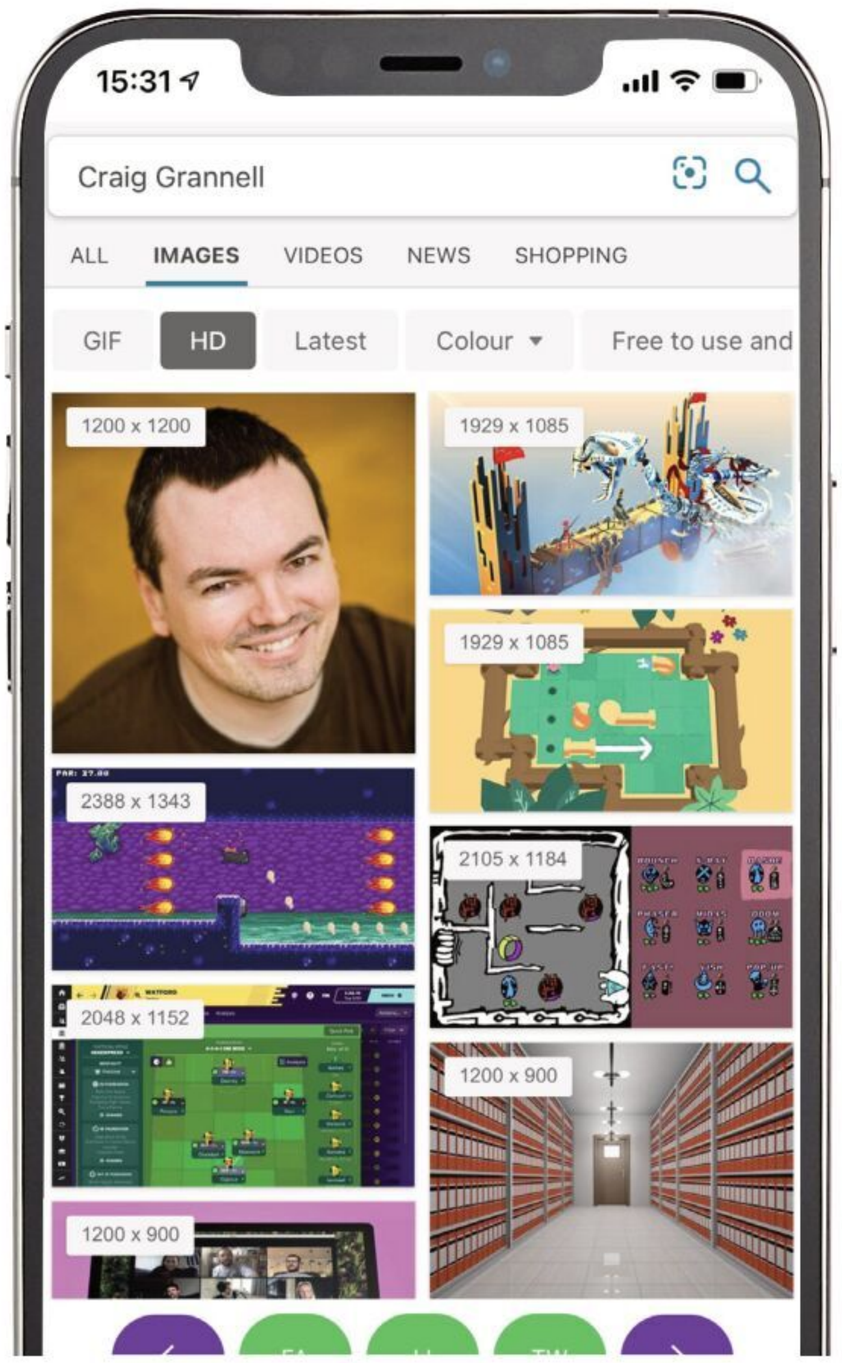
After installing Pocket and creating an account, simply click the Pocket button every time you want to save a web page. You can add tags to saved items, and view your collection by clicking '...' then Open My List.

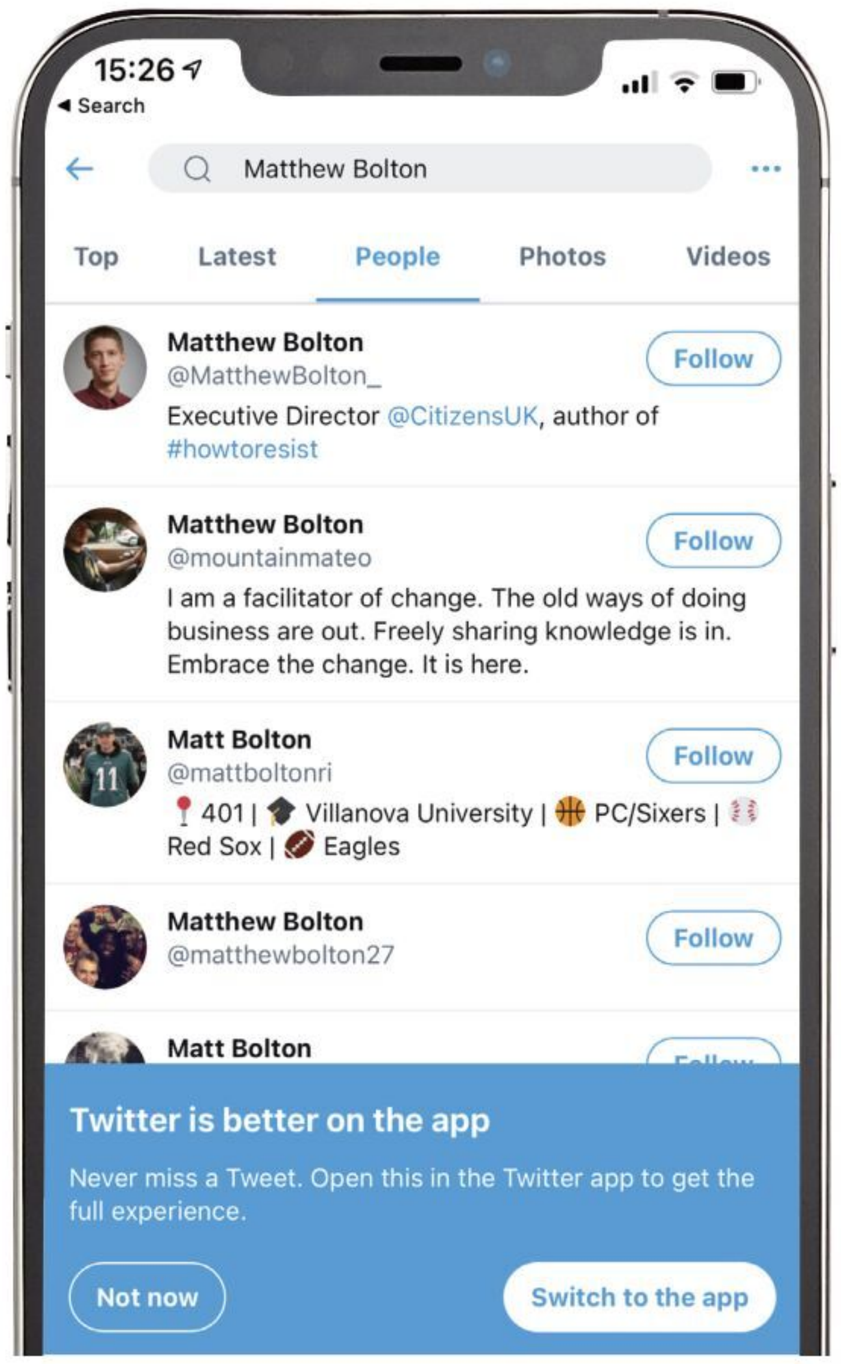
GENIUS TIP!
Make all articles available offline by default by clicking Safari > Preferences > Advanced, then select 'Save articles for offline reading automatically'.



JARGON BUSTER
Safari extensions add extra tools and features to your browser. Open Safari and click Safari > Safari Extensions to find them in the App Store.

GENIUS TIP!
To add your Reading List to your Safari start page, open a new Safari tab, click the three-line toggle button at the bottom, then enable Reading List.





IT WILL TAKE
5 minutes

YOU WILL LEARN
How to quickly add photos to your existing contact

YOU'LL NEED
iPhone, iPad or iPod touch; Contact Pics Adder ($2.99), iOS 14 or later

iOS

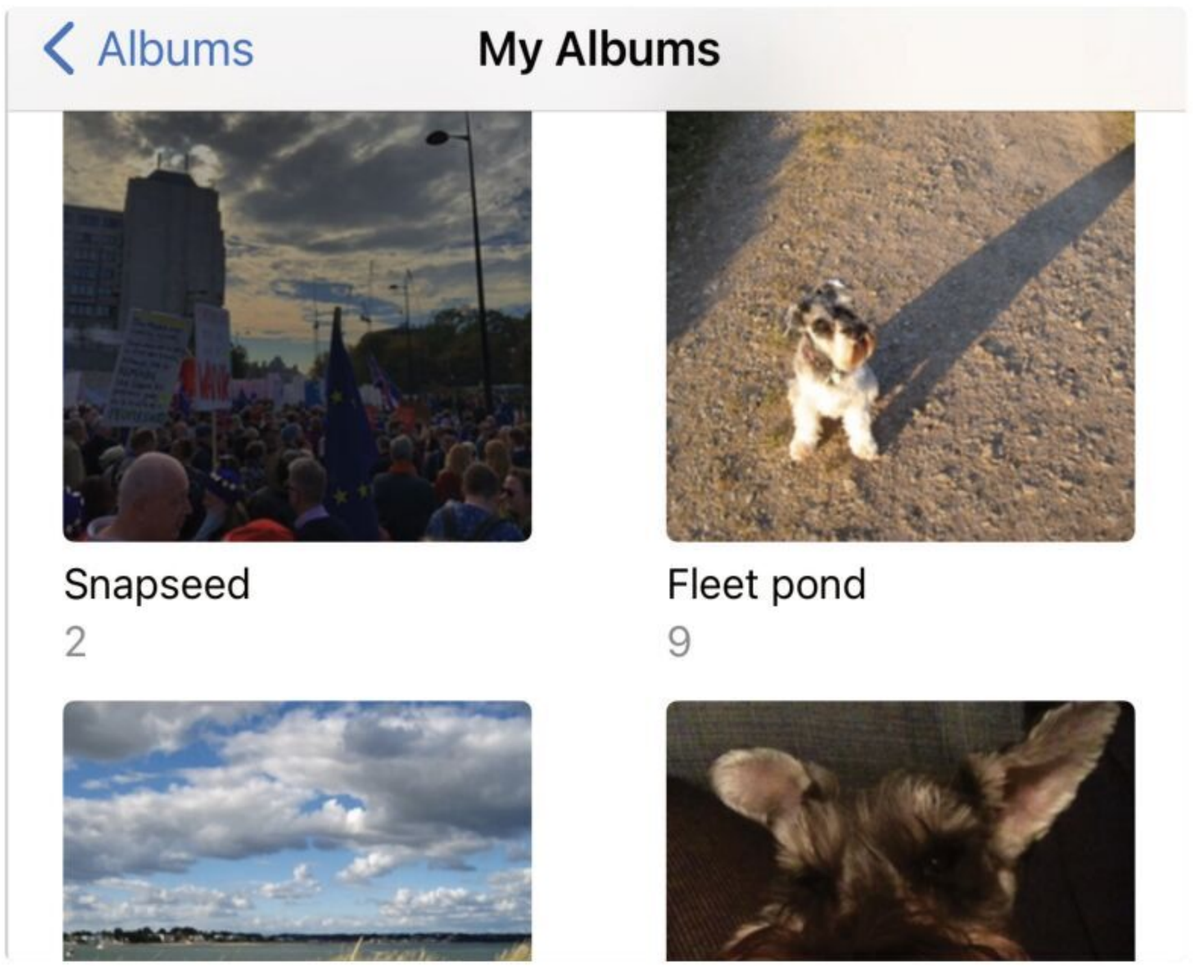
Add photos to your contacts

Use Contact Pics Adder to assign images to all your contacts.

Set up an iPhone or iPad and you're encouraged to take a photo of your beautiful self, which is then added to your card in Contacts. In fact, every card allows you to add a photo (or some other image) to represent that particular person.

Doing so is a smart idea. These images are displayed elsewhere on your mobile devices and Mac as thumbnails. You'll see them in apps like Mail and Messages, providing an at-a-glance indication of who each communication is from. That's good because it's typically faster to browse a list by looking at faces than it is by reading names.

GENIUS TIP!
Contact Pics Adder can mimic the Contacts app's ability to draw images from Photos – just tap Library to use an image from that resource.



Contact Pics Adder doesn't force you to grab images from online sources. If you've something suitable right on your device, you can just tap the Library button and select it.

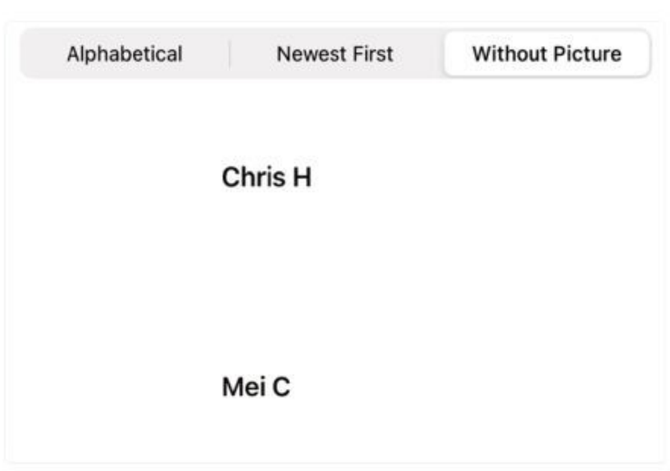
Face it

However, Apple doesn't make it terribly easy to add new photos to your contacts. To do so, you must go into the Contacts app and find a contact without a pic. (Unhelpfully, the main list view in Contacts doesn't show these images.) You can then press Edit and Add Photo, and choose a snap from your library – or opt to depict the person as a Memoji or icon, should the urge take you.

Contact Pics Adder (App Store, $2.99) makes the process far more efficient, speeding everything up by focusing purely on adding new images to your contacts. Our walkthrough shows how to use the app to add images from Bing web searches, Twitter and Facebook. Prior to getting started, we'll assume you've already installed the app on your iPhone or iPad and granted it access to your contacts.

CRAIG GRANNELL

HOW TO Source images for your contacts



01 CHOOSE A CONTACT

Contact Pics Adder initially displays your contacts in alphabetical order. You can opt to display only those contacts lacking an image by tapping Without Picture, or use Search to quickly find a specific person.

02 DO A WEB SEARCH

Select a contact and the app will use their name for a Bing search. A row of blue buttons enables you to refine the search term by using information drawn from that person's details stored within the Contacts app.

03 CROP YOUR IMAGE

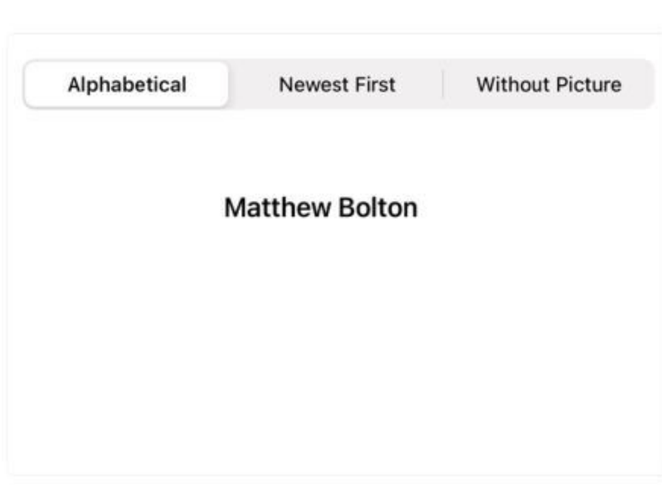
Once you find a suitable image, tap it. In the next screen, drag and pinch to best frame the image within the circular region. When happy with it, tap Save. If you want to revert the contact to how it was, tap Cancel.

04 TRY TWITTER

Should Bing not deliver a usable image, try using Contact Pics Adder's social network buttons instead. Twitter is the simplest option. Tap the TW button and you'll see a Twitter search for your contact's name.

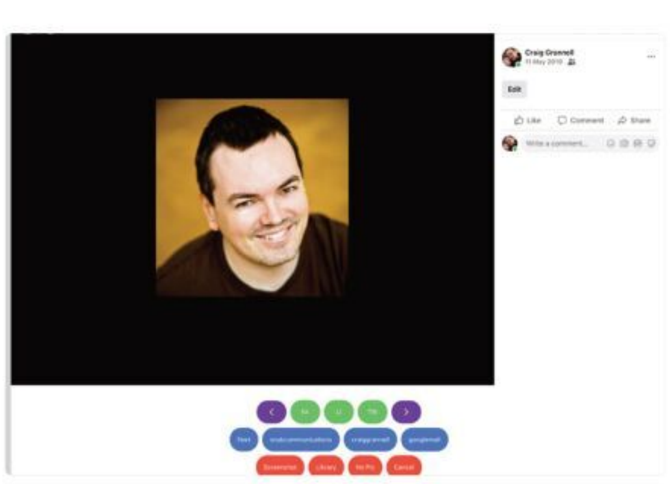
05 FIND A PROFILE

If you don't see your contact but know their Twitter handle, search for it in the Twitter search field. Tap the person's profile image to view it. Tap it again and you'll get the same crop options shown in step 3.



06 REMOVE A PHOTO

Note that should you at any point add the wrong image to a contact, there is no undo. However, you can overwrite any image, or remove an existing image by selecting a contact and then tapping the No Pic button.



07 HEAD TO FACEBOOK

Facebook is slightly more involved than Twitter. First, you'll have to sign into the service. At that point, you can then peruse your friends list, select a photo and add it as normal – if you're using an iPad.

08 TAKE A SCREENSHOT

On iPhone, Facebook has a habit of refusing to load full-size images, or demanding you tag who's in them. Fortunately, Contact Pics Adder enables you to get around this shortcoming by way of the Screenshot button.

09 FINE-TUNE YOUR SNAP

Tap Screenshot and you'll see the crop screen. Resize the iPhone screenshot within the circle so your image fits. Since contact photos are small, screenshot-originated images are of sufficiently usable quality. ■

LINUX

System boot speeds

While Shashank Sharma doesn't much care for cars that can go 0-100 in six seconds or less, he does expect his distro to boot up in no time at all.

All applications and graphical environments are now easily available for just about all Linux distributions. In those instances when they're not offered out of the box, the distribution provides easy mechanisms to install them using software repositories. This is why there's little to differentiate between any two distributions. However, the one area where distributions still fiercely compete with one another is performance: the optimum use of available system resources to boot you to the desktop in the least amount of time possible.

Almost all major Linux distributions now use systemd as the underlying init system. Unlike its peers such as System V, systemd is a software suite comprising various daemons and other system components and utilities. These include systemctl, which can be used to start/stop or enable/disable a service as well as systemd-analyze, which can be used to study boot-up performance statistics. If you find your distribution taking far longer to boot than what's advertised for the same specs, looking at boot statistics might reveal the bottleneck, and help you speed up the process.

Unlike the other applications and utilities we've featured in the past, you don't need to install systemd-analyze because it's part of the systemd suit of applications. When you run the systemd-analyze command, without any other options, the tool will provide the total time taken to boot the system:

```
$ systemd-analyze
Startup finished in 5.656s (kernel) + 1min 6.557s (userspace) = 1min 12.214s
graphical.target reached after 1min 5.129s in userspace
```

As you can see, the command tells us how much time it took to start the kernel, as well as boot up the userspace components. The kernel space includes the kernel and device drivers that need to start when you boot into an operating system. Everything else, be it libraries or other daemons for example, are part of the user space.

From the output of the systemd-analyze command, we can see that it only took about 5.6 seconds for the kernel to start up, but more than a minute for the user space to become active. As you can imagine, this is incredibly slow, especially for a quad core machine with 12GB of RAM installed.

The blame game

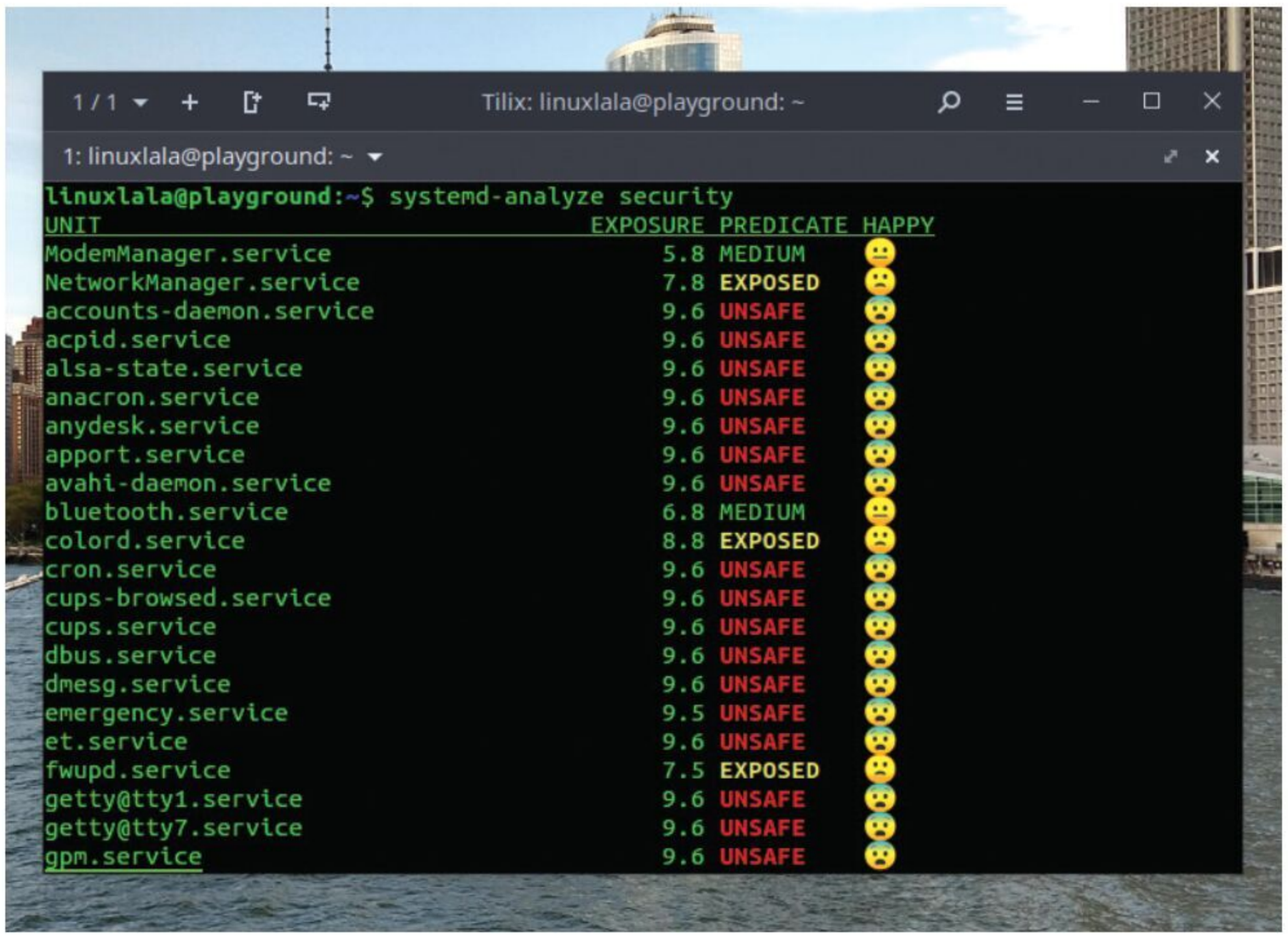
To find out what service is to blame for the boot times, you must run the systemd-analyze blame command and study its findings:

```
$ systemd-analyze blame
28.458s udisks2.service                    >
27.409s dev-sda7.device                    >
23.643s snapd.service                      >
21.156s apt-daily.service                  >
17.497s dev-sda6.device                    >
16.380s networkd-dispatcher.service        >
15.827s systemd-journal-flush.service
```

The actual output to the command is rather long, but we've had to cut it short because of space constraints. You can navigate through the output using arrow keys. The output sorts the different services based on the amount of time taken to start each of them.

Many of the different services start in parallel, which is why the total of these different numbers adds up to significantly more than the actual time reported by the systemd-analyze. This utility gives you some indication of the services that perhaps require closer scrutiny if you wish to improve boot times.

You should also bear in mind that the boot times will vary on each reboot, depending on the changes made to the system by installing or removing applications. In our example, notice how snapd.service takes 23.6 seconds. If we were to remove or stop using Snap packages, and stop or disable the Snap service, the boot times will improve. But you shouldn't start making changes to your system on the basis of the output of the blame command alone.



The systemd-analyze security command can be used to examine the security and sandboxing settings of the different services.

Chain reaction

Some processes during startup cannot begin until some of the other process that they depend upon start successfully. You can obtain a list of all such services

that slow down the boot by making other services wait by using the `critical-chain` sub-command:

```
$ systemd-analyze critical-chain
The time when unit became active or started is printed after the "@" character.
The time the unit took to start is printed after the "+" character.
graphical.target @57.345s
└─multi-user.target @57.344s
  └─smbd.service @53.719s +3.625s
    └─nmbd.service @43.264s +10.452s
      └─network-online.target @43.090s
        └─NetworkManager-wait-online.service @33.967s +9.122s
          └─NetworkManager.service @27.506s +6.459s
            └─dbus.service @27.502s
              └─basic.target @27.366s
                └─sockets.target @27.366s
                  └─snapd.socket @27.361s +1ms
                    └─sysinit.target @27.189s
                      └─swap.target @27.189s
                        └─dev-disk-by\x2duuid-982f7286\x2d84f5\x2d48e5\x2d807e\>
                          └─dev-disk-by\x2duuid-982f7286\x2d84f5\x2d48e5\x2d807>
```

Here, the numbers following the @ symbol show the absolute number of seconds since startup began when the unit becomes active. Similarly, the numbers following the + symbol show the amount of time it takes for the given unit to start.

You can also check the critical-chain of any service by using the systemd-analyze critical-chain <service> command:

```
systemd-analyze critical-chain NetworkManager.service
The time when unit became active or started is printed after the "@" character.
The time the unit took to start is printed after the "+" character.
NetworkManager.service +6.459s
└─dbus.service @27.502s
  └─basic.target @27.366s
    └─sockets.target @27.366s
      └─snapd.socket @27.361s +1ms
        └─sysinit.target @27.189s
          └─swap.target @27.189s
            └─dev-disk-by\x2duuid-982f7286\x2d84f5\x2d48e5\x2d807e\x2de208361fb>
              └─dev-disk-by\x2duuid-982f7286\x2d84f5\x2d48e5\x2d807e\x2de208361>
lines 1-12/12 (END)
```

The data generated by systemd-analyze can be plotted into a graph for easy assimilation.

Run the `systemd-analyze plot > /tmp/systemd-chart.svg` command to generate a SVG chart in the /tmp directory. You can optionally create the chart in any other directory of your choice, if you wish to retain it for future reference.

The command create a SVG file, which is a text file that defines a series of graph vectors. This can then be used by applications such as Image Viewer, Ristretto, LibreOffice Draw to generate a graph. These application can use the data in a SVG file to create an image.

The resulting graph is huge, and you have to zoom in considerably to be able to make sense of the presented data. The graph displays all the services that started at boot, as well as the time it took to start and all dependencies. The critical path for the different services is highlighted in red. Please read the man page of systemd-analyze if you wish to make the most of its capabilities for system manager debugging.

QUICK TIP
There's a simple technique to prevent a disabled service from starting. Just use the sudo systemctl mask <service> command.

We've only covered the most commonly used options of systemd-analyze, but there's plenty more that you can do with it.

Removing bottlenecks

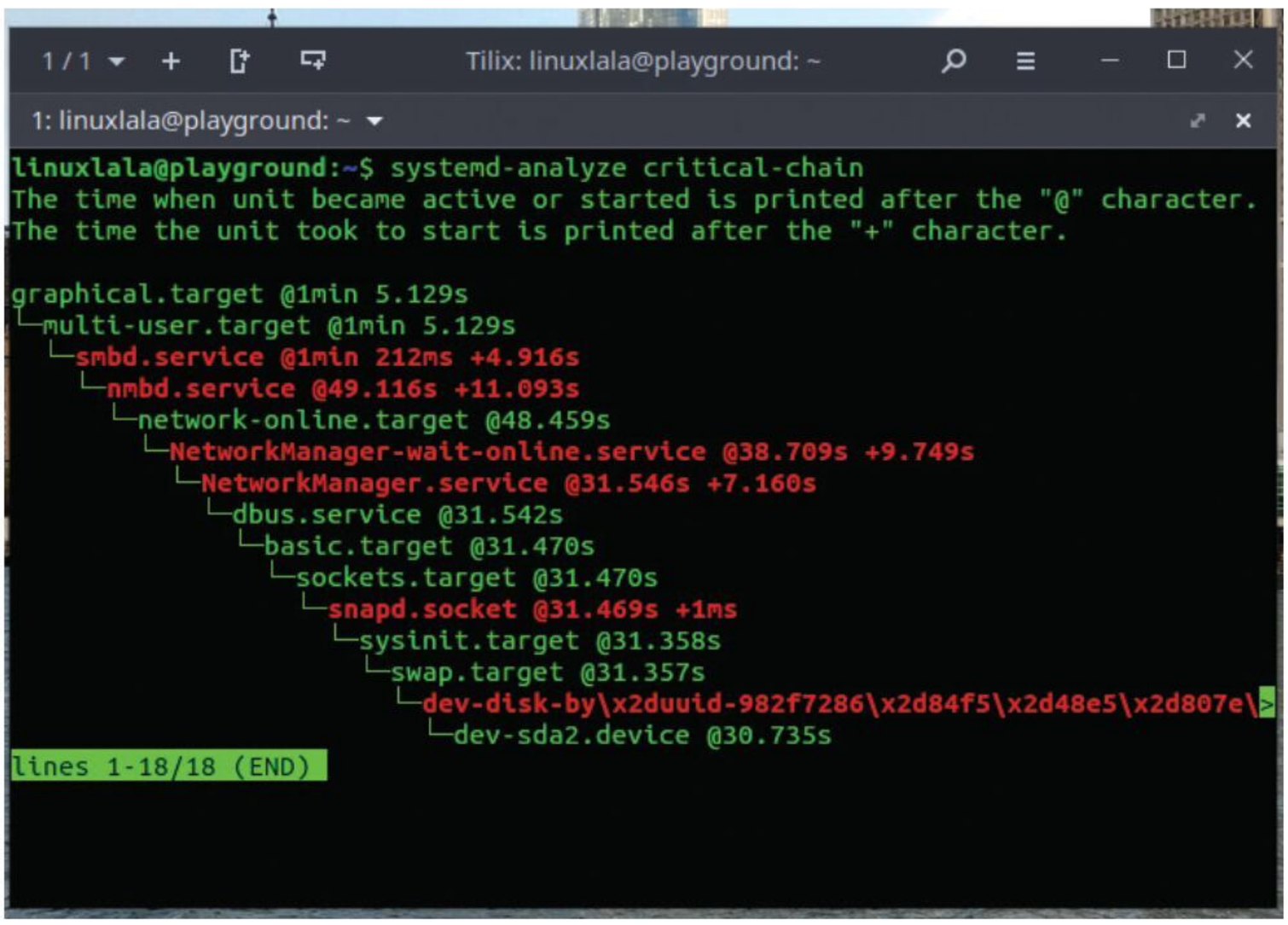
After identifying the bottlenecks responsible for slow boot times, you can use the **systemctl** command to stop and disable unwanted services. For instance, in the example discussed above, smdb, nmdb and networkmanager are some of the services that are holding back other services.

To stop these services and disable them so that they don't start at boot, run the following commands:

```
$ sudo systemctl stop smdb
$ sudo systemctl disable smdb
```

The first command only stops the currently running service, but the second command ensures that the service won't be started automatically at boot. However, even after you disable a service, you might still find it running during a subsequent reboot. This happens when another service depends on a disabled service and starts it. You can get a list of services that might start another service, for instance, smdb or snapd with the **systemd-analyze blame | grep <service>** command. For instance, the command **systemd-analyze blame | grep snapd** will display all the child services that need a parent service.

For a list of all enabled services, you can run the **systemctl list-unit-files | grep enabled** command.



OPEN SOURCE MASTERCLASS

Building code for microcontrollers

Les Pounder introduces a version of Python that we can use on the Raspberry Pi and microcontroller boards.

This month we take a look at CircuitPython, a programming language designed to simplify experimenting with low-cost boards. On a fresh install of Raspberry Pi OS we need to open a terminal and run a few commands to ensure our system is up to date and ready to install CircuitPython:

```
$ sudo apt update
$ sudo apt upgrade
```

Then we install/upgrade setuptools, a Python toolkit to manage Python package installations:

```
$ sudo pip3 install --upgrade setuptools
```

Next we make sure we're in our home directory (/home/pi), then we use the Python packaging tool, pip3 to install Adafruit's Python Shell tool:

```
cd ~
$ sudo pip3 install --upgrade adafruit-python-shell
```

The final two installation steps are to download an installation script from Adafruit, and then run that script using Python 3:

```
$ wget https://raw.githubusercontent.com/adafruit/Raspberry-Pi-Installer-Scripts/master/raspi-blinka.py
$ sudo python3 raspi-blinka.py
```

During the installation it may state that you're using Python 2. It'll prompt you to update – do so. After a few minutes CircuitPython will be installed and ready for use.

Project one – flash it baby!

The humble flashing LED is always the first test for a new electronics project. It enables us to be certain that our code is working and that our wiring is sound. For this project we shall wire up an LED to GPIO 17 via two jumper wires and a 330 Ohm resistor. Please refer to the circuit diagram in the download files for this project.

To write the CircuitPython code we'll use the Thonny editor, found in the menu under Programming. We start by importing three libraries of code. The first is time and this is used to control the pace of our code. The next two, board and digitalio, are CircuitPython specific libraries. Board enables us to interact with the GPIO, while digitalio is used to control the state of a GPIO pin.

```
import time
import board
import digitalio
```

To control our LED, we need to tell CircuitPython where it's connected and that it's an output device. Our LED is connected to GPIO 17, which in CircuitPython is board.D17.

```
led = digitalio.DigitalInOut(board.D17)
led.direction = digitalio.Direction.OUTPUT
```

Inside of a loop we change the value of the LED object to True and False, with a delay, created using time.sleep , between each change. When the value is True, the LED is on. When False the LED is off.

```
while True:
    led.value = True
    time.sleep(0.1)
    led.value = False
    time.sleep(0.1)
```

Save the code and click on Run to start the code. The LED should now flash on and off every 0.1 seconds.

YOU'LL NEED

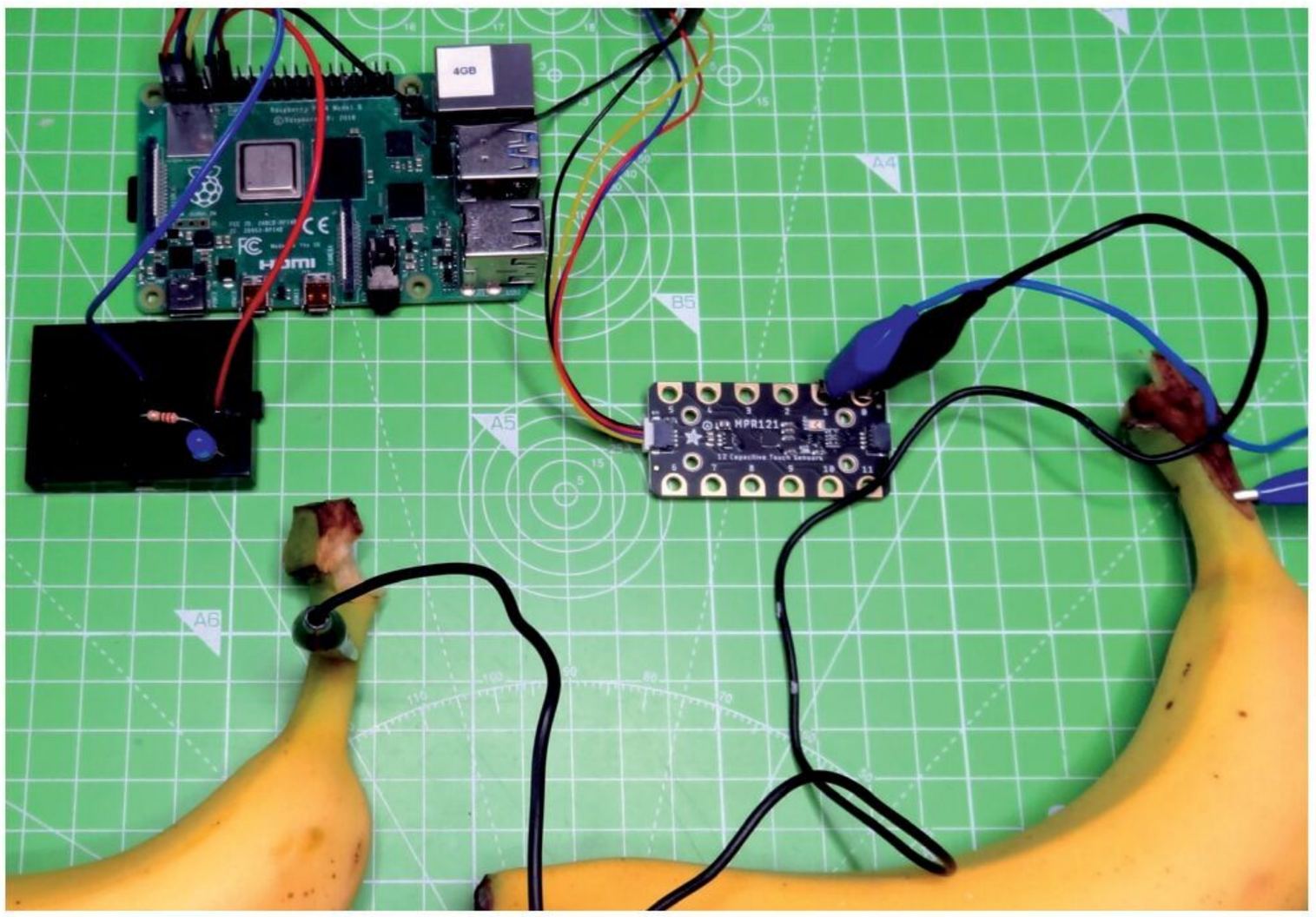
PROJECT ONE

- A breadboard
- LED
- 330 Ohm resistor (orange-orange-brown-gold)
- Two male-to-female jumper wires

PROJECT TWO

- Adafruit MPR121 capacitive touch sensor (**www.adafruit.com/product/4830**)
- Four female-to-female jumper wires
- Two crocodile clips
- Two pieces of fruit
- StemmaQT to breadboard leads (**www.adafruit.com/product/4209**)

All of the code, screenshots and diagrams can be downloaded from **tinyurl.com/APC496PI**



Two bananas, a Raspberry Pi and a little code is the basis of a fun and simple hack to introduce CircuitPython.

Project two – bananas!

The next project requires a little more equipment, but it's no more difficult than controlling an LED. In this project we'll use an MPR121 capacitive touch sensor and a few crocodile clips to enable us to use conductive objects as inputs. The MPR121 is designed for microcontroller boards, but with a little ingenuity we can make it work on a Raspberry Pi. The classic MPR121 example is a banana piano, where touching a banana triggers a note to be played. For our simplified version we'll have two pieces of fruit, and each will turn the LED from Project one

on and off.

To use the MPR121 touch sensor we'll need to install an additional piece of software. Open a terminal and enter the following command:

```
$ sudo pip3 install adafruit-circuitpython-mpr121
```

The MPR121 board uses a StemmaQT connector. To attach it to a Raspberry Pi we need the breakout lead that gives us four jumper wires. They are colour coded as follows: red to 3V, black to GND, yellow to SCL (GPIO3) and blue to SDA (GPIO2). Please see the circuit diagram for a visual guide. Connect the MPR121 to the Raspberry Pi using female-to-female jumper wires. Using crocodile clips, connect a banana to input 0 of the MPR121, attach the other banana to input 1. Any conductive objects will work – aluminium foil and card is a cheap and easy way to make fun touch interfaces. With the board and bananas connected and the software installed we can start writing some CircuitPython code.

We start in the same manner as Project one, by importing the time, board and digitalio libraries.

```
import time
import board
import digitalio
```

The next two libraries are for the MPR121. The first busio enables our code to access the I2C interface that the MPR121 uses for communication. The second enables the use of the MPR121 in our code.

```
import busio
import adafruit_mpr121
```

We reuse the LED object from Project one.

```
led = digitalio.DigitalInOut(board.D17)
led.direction = digitalio.Direction.OUTPUT
```

In order to use the I2C interface our code must know where to find the connection, in this case CircuitPython's busio library can use board.SCL and board.SDA to instantly know their location. We then create an object mpr121 that instructs the code to look for the MPR121 on the I2C pins.

```
i2c = busio.I2C(board.SCL, board.SDA)
mpr121 = adafruit_mpr121.MPR121(i2c)
```

We now get to the part of the code that will check for input. In this case, has a banana been touched? The first banana is connected to input 0. Using MPR121's is_touched() function we can set the input to 0 and use conditional logic (a question) to check if the banana is touched. If so the function returns True and we use that to trigger the indented code. In this case it prints a message to the Python shell, then sets the led.value to True.

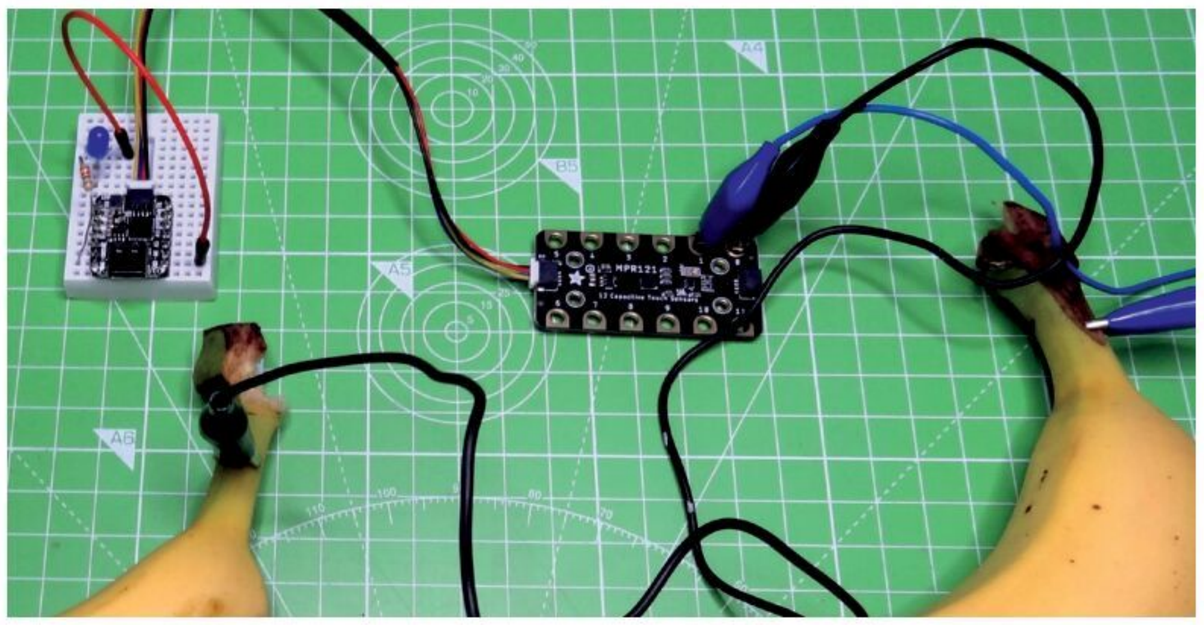
```
while True:
    if mpr121.is_touched(0) == True:
        print("This banana turns light on")
        led.value = True
```

The second banana is our off switch, and using elif (elseif) we can check to see if this banana has been touched. The banana is connected to input 1 via a crocodile clip, and if it's been touched a message is printed to the Python shell and led.value is set to False. Finally, outside of the conditional logic but still inside the main loop we have a half-second pause in the code to prevent accidental activation of the LED.

```
    elif mpr121.is_touched(1) == True:
        print("This banana turns the light off")
        led.value = False
    time.sleep(0.5)
```

With the code complete we can save the file as touch-test.py and click Run to start the code. Now press the bananas to turn the LED on and off. ■

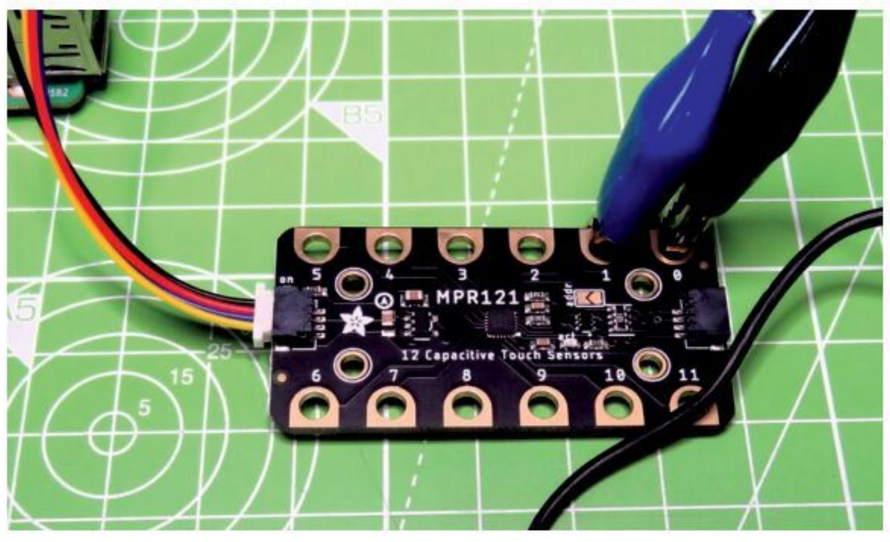
We also built the same project using Adafruit's QTPy board, a tiny board that fits on to the breadboard with room to spare.



QUICK TIP

There are two main editors for CircuitPython. The ideal choice for beginners is Mu (**https://codewith.mu**) that works directly with any board. For the experienced coder, Microsoft's Visual Studio Code is a great choice. For CircuitPython projects on the Raspberry Pi, Thonny is more than capable.

The MPR121 comes in many forms. Our version is designed for use with crocodile clips, but there are others for use with normal jumper wires.



CircuitPython

CircuitPython from Adafruit is a Python-based programming language that works on devices of all abilities and sizes. Our introduction to CircuitPython was via a $4 Gemma M0 board given away at PyCon. This tiny board had very little RAM and a tiny amount of flash storage, but it could control NeoPixels, emulate a keyboard and more thanks to a library of drivers and a friendly community. That same language is what we used in this tutorial.

CircuitPython devices, including the new Raspberry Pi Pico, appear as USB flash drives with a file, code.py, that can be edited in a text editor or a "proper" IDE. Saving the file triggers the board to automatically restart and run the code. Need a library? All of the drivers and software for many different boards are available from **https://circuitpython.org** and we can extract, drag and drop the files where we need them. CircuitPython code is portable, so the code written in this tutorial could also be used on a Raspberry Pi Pico, Adafruit QTPY or Circuit Playground Express.

How we put this project together (don't forget the USB-OTG adapter!).

ATM10a mics

Ammoon AGM02

Samsung Galaxy A30

ANDROID MASTERCLASS

Can you record podcasts on your phone?

It seems like everyone is recording a podcast these days – but can you do it on your phone and can you do it well? Darren Yates splashes $50 to find out.

In case you've missed it, podcasts have exploded in popularity over the last year or so. Got a particular interest? Chances are there's now a podcast for it. But while podcasting's popularity goes up, it seems the cost of the tech to create it has gone up, too. However, there's also been a boom in low-cost audio recording technology, with plenty of budget microphones and mixers now on offer. The big question for me was does any of this stuff work with my phone?

Bigger than Ben Hur

Even recording a podcast just between two people can often seem like a huge production if you watch some YouTube videos. PCs, mixing desks, pricey microphones – it's a lot of gear, which is fine if you're in an office or fixed location. But what if you need something more portable?

We've long said phones are today's true 'personal computers' and although most Android phones are now great at playing high-quality audio, they're still not crash-hot at recording it. At best, you'll find a couple of MEMS microphones in the latest phones, but rarely a bundled audio recording app in sight. So the question is: can you turn your Android phone into a portable podcasting powerhouse?

Podcasting setup

No matter how you do it, a podcast recording setup has three main components – microphones, a mixing console and a digital recording device. The microphones pick up the sound, the mixing console provides control over the audio and converts it to digital data, while the digital recording device simply records the digital stream to storage.

In our case, I wanted to use external microphones for quality and some type of mixer to do the analog-to-digital conversion (ADC) magic, but I wanted the phone to do the digital recording.

Make sure you get a USB-OTG adapter/cable that suits your phone's USB connector.

USB-OTG

One thing most Android phones costing more than $120 have in their favour is USB-OTG. USB 'On The Go' is a bi-directional USB port that allows you to not just plug your phone into a PC, but also plug (some) USB stuff into your phone. Another area where Android has improved is USB audio. Plug in a USB Audio Device-standard digital-to-analog converter (DAC) and you can play your music through the USB port. But we want to go the other way – we need an ADC device to pick up the microphone signal, but also be powered by the phone, be recognised by the

Android OS and also a recording app, something Android rarely includes.

Finding the right app

Google Play has a squillion apps, but we've only found one that does what we need and it's called USB Audio Recorder PRO. It costs around $10, gives you a high-quality audio recorder with built-in software mixer control, live stereo peak-level meters and comes with its own USB Audio Device driver support. That support covers a lot of USB devices, but as you'll see on the website (**https://www.extreamsd.com/index.php/technology/usb-audio-driver**), it doesn't cover every possible device.

Finding a budget USB mixer

I have a pair of excellent Audio-Technica ATM10a omnidirectional condenser microphones, but nothing to plug their XLR connectors into. This is where some intuition came into play.

The key with the USB Audio Device standard is that no separate device drivers are required – just plug the device into your PC, the OS will automatically load its default driver and everyone's happy. The problem is nothing is ever said about Android support.

A quick look on Ebay reveals there are now numerous low-cost mixers available, well under $80. The problem was I needed one that was USB-powered, had an on-board ADC (not all do) and supported two XLR-connected microphones. Without support for bus-powering or on-board ADC, there was no way this would work.

In the end, I found an Ammoon AGM02 mixer. Nice price (about $50), dual Neutrik-style XLR/jack connectors, no device drivers required, it even had phantom-power for the microphones. What I still didn't know was whether it would work with my Samsung Galaxy A30 Android phone. With no mention of Android support, I took a punt and bought it anyway, but the question remained would all this gear go together and work or just fall in a screaming heap?

LEFT: Ammoon's AGM02 is a stereo USB-powered mixer with phantom power and ADC. **RIGHT:** Samsung's now-superseded Galaxy A30 Android phone has USB-OTG support.

Plugging it all together

The AGM02 is about the size of a 3.5-inch hard disk drive, so pretty small, but surprisingly-heavy and feels solid. With the parts on-hand, it was time to put it all together – the microphones via XLR cables into the AGM02's two Neutrik-style XLR-combo sockets, the USB cable into the AGM02 mixer, the other end into the Type-A socket of a USB-OTG adapter and the USB-C end of that adapter into the phone.

For testing, I placed a cheap USB power meter in between the AGM02 and the USB-OTG port to measure the electrical load on the phone. With phantom-power off, the AGM02 power up and measured 20-milliamps (20mA) on the power meter. Switching on the phantom-power pushed this up to a not-unexpected 110mA.

USB Audio Recorder PRO is our favourite Android audio recorder app.

Happily, the USB Audio Recording PRO app recognised the AGM02 as a 'USB AUDIO CODEC' device. I hit the app's 'monitor' button and the peak-level meters bounced around as I did the time-honoured count to 'ten'. The AGM02 was even recognised as a stereo device with 44.1kHz/16-bit CD-level audio support *#winning*.

Drawbacks

Not everything went swimmingly, however. First, the software mixer controls on USB Audio Recorder PRO don't support the AGM02. Still, the actual level controls on the AGM02 are better anyway. The bigger problem was the AGM02's audio-pan controls provided minimal separation between the two channels – roughly 6dB, even when spread to extremes. The issue appears whether plugged into the phone or my Windows PC, so it wasn't the phone or its software.

Recording quality

That was a pity because the audio quality was actually pretty reasonable – microphone input signal-to-noise ratio (SNR) of roughly 65dB, with the AGM02's channel two-band equaliser set flat. Moreover, I wouldn't use dynamic microphones – the AGM02's amplification or 'gain' could only just push the ATM10a microphones' output enough to hit the audio-level end-stops.

The AGM02 also supports instrument pick-ups, so I plugged in an electric guitar and successfully recorded it directly to my phone, again with decent quality. But would I use it to record a two-person podcast? Given the panning issue, only at a pinch. However, the fact that you can plug a USB audio mixer into an Android phone and record high-quality digital audio should at least open the door to finding other options available. Maybe I might even spend more than $50 next time. ■

The original 800 was a large, imposing machine, designed to look like a typewriter, and featured four (yes, four!) joystick ports.

MACHINE OF THE MONTH

Atari 800 Series (1979)

Adding a keyboard to a console.

The Atari 800 series is often overlooked in retro computing, but this machine genuinely put the wind up companies such as Apple and Commodore, establishing an architecture that sold millions of units with a long production run.

On its release, the 800 was ahead of its time and one of the most powerful computers around, bringing innovations such as specialised coprocessors to ease CPU load.

Being an Atari machine, the 800 family features the classic Atari arcade library, but is also an essential experience for fans of '80s micros.

So, let's take a brief history lesson before exploring how you can emulate the 800 line yourself at home. –John Knight

Development and launch

The 800 series was born when Atari realised its console hardware could be expanded upon with a keyboard, and other kinds of I/O, to make a television-based micro. The Atari 800 would be the foundation upon which other models could follow, using the same basic chipsets and architecture.

Launching in November 1979, Atari's initial lineup consisted of two models: the fully featured 800, and the stripped-down budget model 400. The 800 had two cartridge ports, four expansion slots, and a proper keyboard; the 400 had one cartridge port, two expansion slots, and an inexpensive childproof membrane keyboard.

Both machines ran a highly clocked MOS 6502 @ 1.79MHz, with 8KB of RAM. The 400 could be expanded to 16KB, while the 800 could take up to 48KB. The 400 would later sell with 16KB and the 800 would sell with its maximum 48KB. The 400 sold twice as many units as its big brother.

Colour handling is the Atari's showpiece. Often referred to as 128 colours, the Atari featured "16 colours each with 8 intensities".

After several years of Atari leading the market, the aggressively priced Commodore 64 forced Atari to adapt the 800 series with lines like the XL series. These could use more RAM, thanks to new variants of the 6502 CPU, and cut features rarely used on the 800.

Atari had a false start with its poorly received 1200XL, which was too expensive and not entirely backward compatible. However, the company found new success with the 800XL, a smaller, cost-reduced, simplified version of the 800, with 64KB of RAM. It was paired with its 600XL little brother, which shipped with 16KB of RAM, expandable to 64KB.

It might be blocky but *Alternate Reality: The City* (1985) shows off the Atari's superior colour system over other 8-bit micros.

Gaming

The 800's gaming scene generally sits in two categories: earlier games, which were largely ports from Atari arcades, and later games from the '80s microcomputer scene.

The 800's arcade ports are usually better than on the 2600 console, with more detailed graphics and additional gameplay elements. As for 8-bit micro gaming, the Atari probably sits somewhere between an Amstrad CPC and a Commodore 64.

Unlike many rivals, the Atari has proper hardware scrolling. While the Atari's POKEY sound chip isn't as good as Commodore's SID chip, it is respectable nonetheless. And among the main 8-bit micros, the Atari probably has the fastest CPU. But when it comes to colours, the Atari destroys the competition, with abilities more like a 16-bit

SPECIFICATIONS **CPU**: MOS Technology 6502 @ 1.79MHz **RAM:** 8KB to 48KB **Graphics**: 16 colours x 8 intensities @ 160x96, monochrome @ 320x192 **Sound:** POKEY I/O chip, 4× oscillators with noise mixing, or 2× AM digital **Storage:** Cartridge, cassette,5.25 Inch floppy **OS:** Atari BASIC, Atari DOS **Released:** November 1979 Production: 1979–1983 **Worldwide sales:** 4.5–5 million

machine. On the downside, the Atari has weak sprite handling and a low resolution, with blockiness like an Amstrad on a bad day. And because of developers supporting machines with less RAM, Atari ports often cut features available on rivals.

Nevertheless, numerous Atari ports were superior to rival machines and there are plenty of exclusive titles worth trying. To pick some gaming highlights, *Star Raiders* (1979) provided early 3D space flight and was the Atari's "killer app." *Rescue on Fractalus!* (1984) is an early experiment in first-person fractal-generated landscapes. *Alley Cat* (1984) is much better than its PC equivalent, and *Ballblazer* (1984) is better than on all other machines, 8 or 16-bit.

Legacy

As the 1980s dragged on, software support was becoming increasingly scarce. Despite this, Atari kept the 800 series going with refreshes, such as the XE series, which was styled to look like a 16-bit Atari ST and could take 128KB of RAM, and the XE Game System console, which came with a lightgun.

Atari finally ended support for the 800 series in 1992, having sold between 4.5 and 5 million units.

Emulation

Of the numerous emulators available, we like Altirra and Atari800. Altirra is much more user-friendly, while Atari800 has a retro-style interface that veterans may love. Atari800 has versions for Windows and Linux, but Altirra only has a Windows version, though it works well through Wine.

While both emulators now have open-source replacement system ROMs, proper system ROMs will give the best compatibility. Luckily, legally available ROMs are available through another emulator, XFormer. We wouldn't recommend XFormer to casual users, but we can at least use its binaries. The Atari800 download page has a link to an older version – just unzip the package and we will point to it in a moment.

A final tip: If you get stuck at a game's title screen, try pressing F2, which is the standard Atari key for "Start," while F3 is "Select."

© © Evan-Amos/wikimedia, Freeware

Yoomp! (2007) is a modern classic from the Atari 800 community, which is still making games and demos for it.

YOU'LL NEED

ALTIRRA
For more casual users: **www.virtualdub.org/altirra.html.**

ATARI800
Advanced users: **https://atari800github.io/download.html.**

ALTIRRA: BEGINNERS

The Altirra homepage (**www.virtualdub.org/altirra.html**) provides a ZIP file with Windows binaries. Download and extract the file, and in the Altirra program folder will be two executables: Altirra.exe for 32-bit systems and Altirra64.exe for 64-bit systems.

Once opened, Altirra runs a First Time Setup wizard. Click "Next" and in the "Setup firmware" section is a "Scan folder for firmware images" button. Skip this if you want to try the replacement ROMs; otherwise click it and choose the folder where XFormer is extracted, then proceed to the next section.

In the "Select system" section, keep the default choice of "XL/XE Home Computer" and click "Next." The following screen has a choice of NTSC or PAL. This can be changed later on, but for now choose NTSC if you plan on mostly playing US games, or PAL if you're more likely to play European titles. Keep clicking "Next" until you reach the "Finish" button.

To get started running software, from the main menu click "File > Boot Image," and choose your file.

Unfortunately, no joystick devices are enabled by default – not even keyboard-based joystick emulation.

Enable a joystick by clicking "Input > Port 1," and then selecting a device from the given list. The first choice, "Arrow Keys > Joystick (port1)," uses the arrow keys for movement and Left Ctrl for fire.

Atari800: advanced

Make sure you use the newest version of Atari800, which has cleaner code and a open source replacement ROM. If you're stuck using an older version, externally sourced system ROMs are needed to play anything at all.

At the website's download page (**https://atari800.github.io/download.html**), follow the Atari800 GitHub link, which has downloads for Windows, .deb packages for Linux, plus source code.

For the Windows version, download the win32 ZIP file and extract the contents into a new folder. Inside this folder is the atari800.exe executable.

For Linux users, if you can't install the .deb packages, a Snap is available with an older version. Once installed, Atari800 should be in your system menu, or can be run with this command:

```
$ atari800
```

Once inside the emulator, press F1 to access the system menu. Atari800 will be running in a tiny window, so first open "Display Settings > Video mode settings" to increase the resolution or enable full-screen.

If you want to use the XFormer system binaries, from the main menu choose "Emulator Configuration > System ROM settings > Find ROM images in a directory." Now, from the file browser that appears, navigate to the extracted XFormer folder, and once inside, press Space.

By default, Atari800 has joystick 1 set to the number pad, with Right Ctrl as fire. ■

DOWNTIME

THE FUTURE OF FUN TOMORROW – TODAY

GAMING NEWS

The biggest PC gaming news from E3 2021

The games *APC* is most excited about.

Virtual again this year, we didn't get to gather in sweaty, heaving crowds for E3 2021, but it was a big one nonetheless. Across the Summer Game Fest, the Guerrilla Collective, Microsoft's Xbox-Bethesda Showcase, the PC Gaming Show, and other online events, we saw an astonishing – nearly overwhelming – assortment of new game announcements, release dates, and other news.

STALKER 2: HEART OF CHERNOBYL

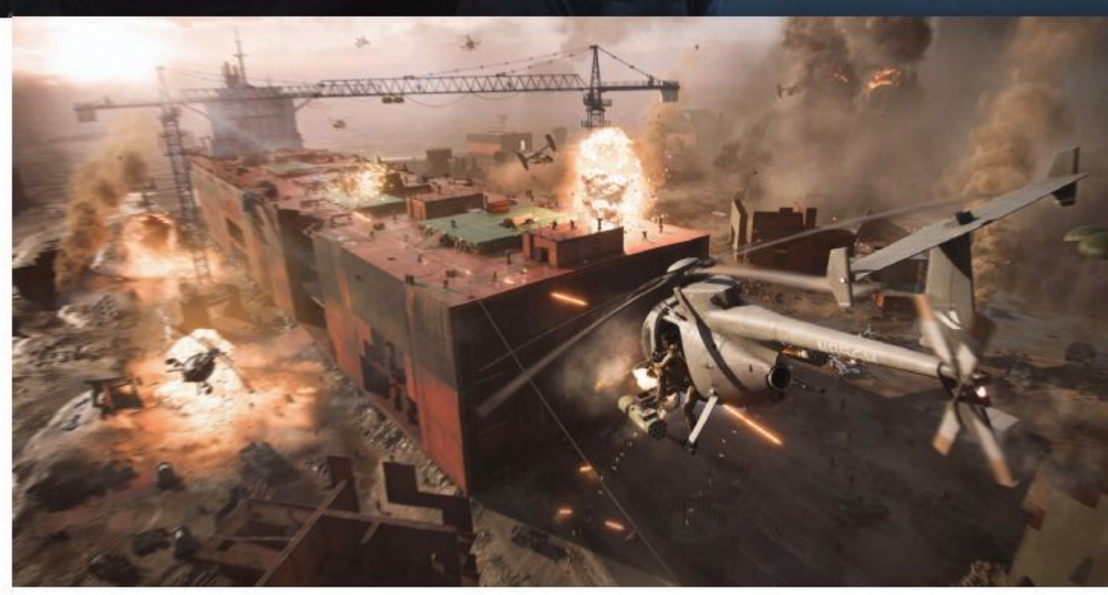
What is it? A post-apocalyptic horror FPS, and sequel to the first game that came out over 12 years ago.
When's it out? April 28, 2022.
What did we see at E3? A new trailer with both cinematic sequences and gameplay. There's not a lot to go on, but there's plenty of banter between fellow fireside campers which shows the game's humorous streak, lots of industrial shootouts, and a look at a bloodsucker, and an interesting piece of new hardware. A bit too much shooting for *Stalker* honestly.

AGE OF EMPIRES 4

What is it? The return of an RTS classic to warm our hearts.
When's it out? October 28.
What did we see at E3? A cinematic with Joan of Arc, and some gameplay reminiscent of the fondly remembered *Age of Empires 2*. There were war elephants, French knights, trebuchets, camel-mounted archers, a naval battle, and walls that will hopefully have those gates you could open and close by clicking on them.

ATOMIC HEART

What is it? The Soviet sci-fi FPS we're all waiting for.
When's it out? TBA.
What did we see at E3? A glorious minute of madness. Sinister robots, one with a head full of fruit. Frozen explosions. Cybernetic implants. Lightning powers. Levitation. A babushka with a soup ladle. It looks incredible.



TOP: We all hope and pray that *Stalker 2* is as incredible as the legendary original.
ABOVE: The new chapter in the *Battlefield* series is a visual spectacular.

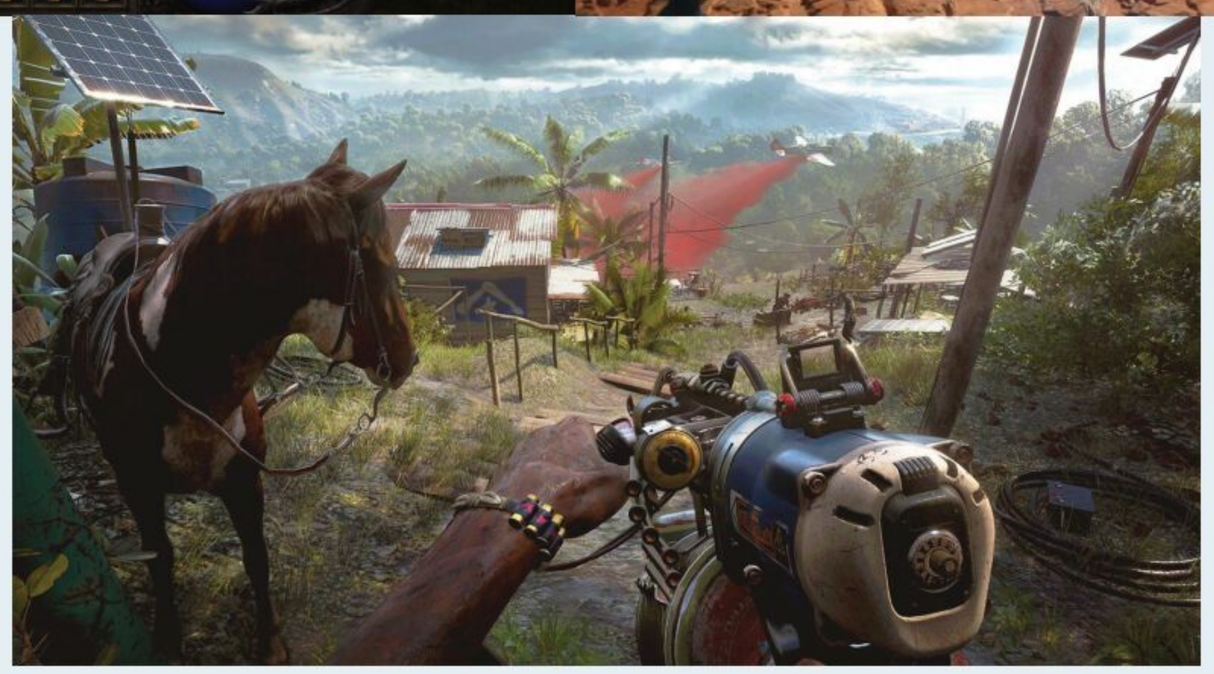
BATTLEFIELD 2042

What is it? A near-future Battlefield that increases match size to 128 players and introduces specialists with gadgets (kind of like *Rainbow Six Siege* operators, but they can carry any gun).
When's it out? October 22.
What did we see at E3? The reveal preempted E3: You can watch the first trailer on YouTube, and we'll have more *Battlefield 2042* details soon. There's no singleplayer and no battle royale mode in this one, but there are a couple mystery modes we'll learn about in the future. We'll see the first gameplay trailer during E3 proper on Sunday, June 13, and then we'll see more in July at EA Play Live.

DIABLO 2: RESURRECTED

What is it? Blizzard's classic action-RPG in modern resolutions, running at 60 fps.
When's it out? Sep 23, 2021.
What did we see at E3? Our first look at the newly recreated cinematics, which sure are shiny.

LEFT: Veteran gamers are united in their excitement for a truly new *AOE* game, including most of the *APC* team! Keep the dream alive!



ABOVE: Most PC gamers will have fond memories of *Diablo*, prepare for more!
ABOVE RIGHT: The big impact *The Outer Words 2* made on E3 was it's ridiculously funny trailer.
RIGHT: Prepare for more lush environs, OTT violence and cult skulduggery in *Far Cry 6*.

Otherwise, in spite of the graphical improvements, it's still good old *Diablo 2* as we remember it. We also found out multiplayer beta will take place in August.

EVIL DEAD: THE GAME

What is it? What else could an official Evil Dead game be, but a cooperative zombie slayer reminiscent of *Left 4 Dead*?
When's it out? It's coming in 2021 – exactly when is yet to be confirmed.
What did we see at E3? The reveal trailer above was shown during the Summer Game Fest. In addition to revealing all the key facts and a very life-like Bruce Campbell, it shows off some grim horror environments fairly reminiscent of *Friday the 13th: The Game*. Morgan has the full rundown on the four-player melee co-op game here: he liked the look of it.

FAR CRY 6

What is it? Giancarlo Esposito is an evil dad and you need to go shoot lots of his henchmen in lush, outdoor environments.
When's it out? October 7.
What did we see at E3? One of those villain speeches where the bad guy is charismatically menacing at a group of people.

FORZA HORIZON 5

What is it? A very pretty game about driving cars fast. This time the series is heading to Mexico.
When's it out? November 9, 2021.
What did we see at E3? Lots of shiny cars going real fast in picturesque environments. The trailer for *Forza Horizon 5* is one of the prettiest yet with some huge dust storms, lush vegetation, and volcanic scenes. Combined with the new ray-tracing lighting tech and super detailed photogrammetry textures, Forza is looking good and is potentially the most impressive and exciting game of the show.

MARVEL'S GUARDIAN'S OF THE GALAXY

What is it? Singleplayer superhero shenanigans in which you are Star-Lord.
When's it out? October 26.
What did we see at E3? A debut trailer and a deep dive confirming that this is not a live-service game and won't have microtransactions or DLC. Instead, it's a narrative action game where you get to jet-boot around as Star-Lord, calling on the other Guardians when you need their special abilities. It's drawing from the movies and the comics, and no, you don't get to look like Chris Pratt.

THE OUTER WORLDS 2

What is it? The sequel to Obsidian's corporate-satire sci-fi RPG.
When's it out? No clue.
What did we see at E3? A parody of videogame trailers that's funnier than most of the jokes in the first *Outer Worlds* were. But it didn't leave us with much to go on. The description did hold a few clues: "New solar system, new crew, same Outer Worlds," it reads.

PSYCHONAUTS 2

What is it? The long-awaited follow-up to one of the quirkiest and most beloved platformers in PC gaming history.
When's it out? August 25, 2021.
What did we see at E3? Raz exploring more of the weird and wacky worlds that exist inside of his friends' subconscious minds. It's pretty silly, which is what we want from *Psychonauts*. The release date is the big news of course.

STARFIELD

What is it? The next big RPG from Bethesda, in spaaaace.
When's it out? Nov 11, 2022.
What did we see at E3? An honest-to-goodness release date. The trailer didn't tell us much, but Todd Howard's been talking and that's how we know *Starfield* will have various factions to join: "It's kind of like *Skyrim* in terms of the structure of the game, where you're going to be who you want to be, and then there's different factions that you can join, and really carve your own path."

WARHAMMER 40,000: CHAOS GATE – DAEMONHUNTERS

What is it? Turn-based tactics, a successor of sorts to 1998's *Warhammer 40,000: Chaos Gate*
When's it out? 2022
What did we see at E3? A teaser showing that we'll be playing the Grey Knights, the psychic warriors of Chapter 666 who battle Chaos on behalf of the Inquisition. If the buzzing flies weren't enough of a clue, the shambling poxwalkers at the end suggest that those enemies will be the daemons of Nurgle, Warhammer's grotesque plague god. We'll find out more when the cinematic trailer comes in August. ■

GAME REVIEWS

TIS THE SEASON TO BE GAMING MADLY

$54.95 | PC, PS4, XB1, Switch | bit.ly/2RZmBlo

Warhammer Age of Sigmar: Storm Ground

A universe has its PC debut.

Like so much Warhammer spawn, *Storm Guard*'s lore and fine writing flatter a flawed game that clumsily combines tactical turn-based combat with an odd roguelike metagame.

You start each battle with a single hero unit. As you amass 'Power' over the turns you can call in subsequent units using cards that you earn over a campaign-run by completing missions and looting chests in battle. *Storm Ground*'s three factions cater to different playstyles. You have your straightforward Stormcast Eternals – humans donning heavy armour and divine judgement. The Nighthaunt are a ghostly faction of low-armour, fast-moving swarmers, whose hero can throw down healing wisps each turn to heal allies and summon pyres all over the battlefield to act as spawn points.

Then there are the wonderful Maggotkin, whose playstyle is based around plopping down puddles of green corruption which heal allies, damage enemies, and let you spawn units. This makes for an interesting dynamic, as your tiny Nurglings scamper around shitting green goop while the enemy desperately gives chase, only to get reeled in by the gut-tongues of your tanky Putrid Blightkings or spewed upon by the airborne Blightlords.

Beyond your regular melee and ranged combat, you can knock back and shove enemies around the battlefield, chaining damage in a similar way to the excellent kaiju-bashing classic *Into the Breach*. Knock a Nighthaunt Banshee into its allies, for instance, and if it dies it will explode on death, knocking enemies back even further and causing them to scatter in fear from its death screech.

But beyond these moments, the hex-based tactical combat is lightweight. The maps are flat and scarce, with the only terrain advantages being single-level ledges of high ground to clamber up to.

Then there's the lumbering roguelike structure, prolonging each campaign even though they're perfectly long enough without the relentless restarts. In *Storm Ground* you can put in untold hours before a single wrong move unravels your entire campaign, and no amount of levelling, cards, or new units you unlock for subsequent runs makes up for the drudgery of having to redo those hours again with little variation.

It gets worse. Once you complete a chapter you permanently unlock the second chapter in the campaign menu. So you'd think that you get to continue your hero's journey from this point at your leisure, right? Nope. When you click to play the next chapter, you restart the entire campaign at a higher difficulty, and only after trudging through that for hours do you get to progress your campaign into the next chapter.
ROB ZAK

A straightforward tactics game buried beneath a mountain of roguelike metagame.
★★½☆☆

$21.50 | PC, Linux, Mac | wadjeteyegames.com/games/strangeland

Strangeland

Lives up to its name, if not its promise.

Publisher Wadjet Eye has a reputation for great modern point-and-clicks, both developing its own titles and helping others' projects to launch. *Strangeland* feels at home in that stable, but it struggles to live up to the company's better efforts.

Upon entering the carnival, you find a woman tearfully throwing herself down a well. Although your character's memory is gone, he knows that she means something to him, and so the objective of the game is to save her. You'll repeatedly see her jump in, each time unable to stop her, and as you progress she haunts your journey.

Strangeland walks a darker path than you might typically expect from the genre, but it still follows certain rules. You have an inventory, you can combine items before using them, there are puzzles typical of the genre – it's all very familiar. Slightly less common, but present here and very much welcome, are multiple endings. It's not entirely clear how many there are or how to access them, but I found three new ones by reloading the final autosave. One was extremely grim; all felt surprisingly abrupt.

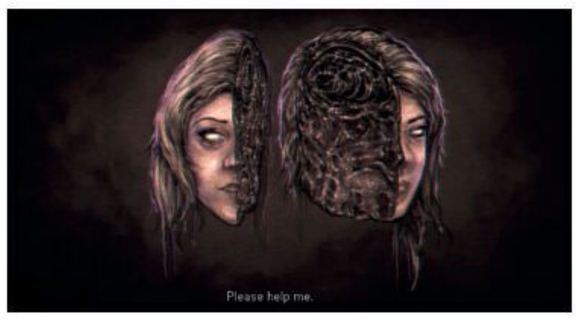
The art is superb. Anything that isn't run down or twisted is strangely organic; the environments are flavoured with a hint of HR Giger. This means they can be difficult to immediately discern fine detail in, which means that objects you can pick up or interact with can be easy to miss. This is sometimes the greatest challenge that a puzzle presents, as most of them are otherwise pretty simple.

If you're just looking for a surreal horror adventure, *Strangeland* can absolutely deliver that. However, the further you stray from the developer's messages and intention, the more difficult it is to enjoy. The conundrum is this: Considered purely as a point-and-click game, it's not great. Considered purely as an artful exploration of difficult subjects, it's largely a success. The truth of the situation, of course, is that it's a mix of the two.

LUKE KEMP

Strangeland's compelling narrative is very strong and dark, but the game beneath it struggles to keep up with it all.

★★★½☆



Free | PC, Linux, Mac | bit.ly/oceanwork

Oceanwork

A snack-size *Subnautica* in mysterious diving game.

apc RECOMMENDS

The world of *Oceanwork* is an incredibly bleak one. As the perpetrator of an unspecified crime, you're rocketed onto a watery planet to rinse it of its natural resources. When you've mined enough metals – and then banked them in exchange for cash – you can buy your freedom for the very reasonable price of 30 million credits.

Oh, it's a joke number at first, as you dive into the ocean again and again, chipping bits of copper in exchange for chump change. But as you exchange that change for upgrades – a bigger air supply here, a sharper pickaxe there – you can delve deeper into the ocean, where the rarer, more valuable minerals lie.

If all that sounds eerily familiar, then you're probably thinking of *Subnautica*, which does the aforementioned stuff but over quite a few hours, and over quite a big ocean full of sea creatures, wrecks, and alien mysteries. *Oceanwork* compresses it down to an hour or two, while looking like it was regurgitated by a PlayStation One. But it's a big enough sea, and beautiful in its own way.

TOM SYKES

The cliff-notes version of *Subnautica*, if it had existed on the original PlayStation.

★★★★☆

Free | PC, Mac, Linux | motvind-studios.itch.io

How We Know We're Alive

Homeward bound.

In this affecting adventure game, you play as a woman returning to her home town in Sweden, a year after the death of her childhood friend. The place hasn't changed, and it's with bitterness rather than nostalgia that she wanders the streets, chatting to the locals as she tries to understand what happened.

The mystery is dangled in your face before being deconstructed at the close of the game. While it has the atmosphere of a *Twin Peaks*-style mystery – as you explore a quiet, rural town impacted by a shocking event – it's a subtler story than I was expecting, offering no neat resolution to your friend's sudden death. The ending is devastating, and without relying on violence. A few carefully chosen words can twist the knife just as well as an actual weapon.

There's a duality to small town life that *How We Know* captures nicely. These might seem beautiful towns that many would want to live in, but they can feel suffocating when you're growing up.

TOM SYKES

Explores small town duality in an understated and thoughtful manner.

★★★★☆

$44.99 | PC, PS5, XB1, Switch

Subnautica: Below Zero

A survival game with depth.

Subnautica: Below Zero is almost as good as *Subnautica*. This may sound like damning with faint praise, but since *Subnautica* is, to my mind, the best survival game ever made, I'd argue the praise is pretty darned clear. Although less consistently brilliant, *Below Zero* shares the wild imagination, adventurous spirit, and richly tactile systems of its modern classic of a predecessor.

Below Zero returns players to the marine planet 4546B, this time donning the flippers of a new protagonist named Robin Ayou. Robin is searching for her sister Sam, who according to Sam's employer Alterra, was accidentally killed while on a research expedition to the planet's arctic region. But Sam's previously recorded messages to Robin tell a different story. Arriving alone with minimal supplies on an unsanctioned search and recovery mission, Robin must follow her sister's trail while surviving the harsh climate of 4546B's arctic.

This environment is *Below Zero*'s primary new feature, and the main area where the sequel improves over *Subnautica*. 4546B's icecap introduces a suite of new biomes for players to explore. Beyond a familiar introductory area of shallow coral and fluttering kelp, the aquatic topography includes giant lily-pad forests, shimmering crystal caves, and bubbling vents that explode if you get too close. In addition, it introduces several new land biomes, all of which carry the game's arctic theme.

The new polar terrain enables *Unknown Worlds* to bring *Subnautica*'s survival play onto land. When you breach the surface of the alien ocean, your O2 metre swaps out for a temperature gauge that slowly depletes.

Not all of *Below Zero*'s changes are so welcome, however. The story is far more present than *Subnautica*'s. Characters are much chattier and there are even NPCs who appear on-screen. But the result is a less engaging story.

Again though, it's vital to stress that even the 'bad' bits of *Below Zero* are good by most other standards. It may not better than *Subnautica*, but it remains a hugely accomplished piece of work, and the second-best survival game after its predecessor.

RICK LANE

Unknown Worlds does it again! *Below Zero* is a mostly brilliant sequel to one of the best survival games of all time.

★★★★☆

$35.95 | PC | kingofseas.net

King of Seas

Enjoying the good kind of videogame piracy.

Here's a pirate simulator that makes being horrible on the high seas really fun. If all you want is something that lets you wander around being pirate-y, this will serve you very well indeed.

Controls are nice and simple. Speed is dictated by how many of your three sails you have unfurled, which means taking a few down for tight turns, which can come in handy during combat. Speaking of which, to begin with, you'll rely on your cannons. Shooting to the left or right of your ship, positioning and awareness of range is important, as is timing; they take a few seconds to reload each time

There's a huge number of upgrades to find, loot and buy. Aspects such as hull, crew, and sails will affect attack and defence stats, but after a little while you'll also start to come across special abilities, most of which are magical. It seems unlikely that real pirates were using flamethrowers and magical beams of energy, or summoning giant tentacles to attack their enemies from the sea, but I bet they would if they could.

Roughly three quarters of the way through, it introduces the idea of conquering ports. This is a horrible idea. Attacking the gun emplacements that defend these ports simply isn't very fun. None of your special abilities can touch them, which means that conquering ports involves little more than doing laps of the emplacements, slowly chipping away at their health, until either you or they explode.

Despite the flaws in nudging the player along, I enjoyed most of my time with the game. Sure, after eight hours or so I started to wish for a better-structured experience that I could dip in and out of, but that doesn't change the fact that this is a great sandbox to mess around in. The need to make your own fun means this isn't a game for everyone, but for my part, I love the fact that I can be as mean or moral a pirate as I like.
LUKE KEMP

The developers of *King of Seas* arrrrre pretty great at making pirate games.
★★★½☆

Free | PC | fallahn.itch.io

Purcitop Garden

Lost in shrubbery.

Here's a game about solving mazes, which takes place in the biggest garden this side of Babylon – so vast it's split up into several procedurally generated levels. You're there to meet your uncle – the inventor Professor Eustace – but first you have to fathom your way around his sprawling garden.

From a top-down perspective, you'll trudge through a series of mazes hitting dead ends and doubling back on yourself, before finally acquiring the key to each exit and moving on. This simple act of orienteering is soon expanded with NPCs, acquirable tools including hedge trimmers, and occasional minigames in a variety of genres. There's bags of content here, and it's all whimsical, giving off the vibe of a cosy old children's novel set in the English countryside. You'll talk to foxes, race snails, and insult gnomes. *Purcitop* throws everything up the garden path to make its mazes more interesting.
TOM SYKES ■

If you can put up with a bit of gruel, there's an excess of charm inside this weird and whimsical garden.
★★½☆☆

TLOTRO's combat is clunky and derivative.

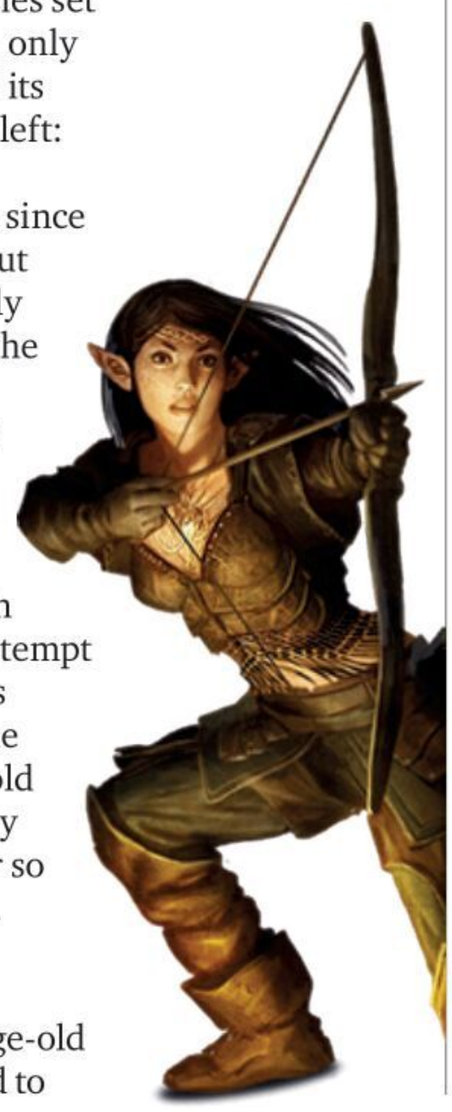
DEVELOPER STANDING STONE GAMES **PUBLISHER** DAYBREAK GAMES **RELEASED** 2007 **WEB** TLOTRO.COM

The Lord of the Rings Online

A bittersweet return to Middle-earth.

I deeply miss those brief few years when *The Lord of the Rings* had taken over the world. It wasn't just the movies but all the spin-off games too – those incredibly fun action-RPGs based on the movies, real-time strategy games like *Battle for Middle-earth*, and even the surprisingly great *Middle-earth: Shadow of Mordor* and *Shadow of War*. But of the dozens of games set in Tolkien's fantasy universe, only one has successfully wormed its way into my brain and never left: *The Lord of the Rings Online*.

I've easily spent more time since its 2007 launch thinking about playing *TLOTRO* than actually playing it. I'm enchanted by the idea of a fully explorable Middle-earth, but MMOs are big, time-consuming games. Despite a few attempts, I just never got into *TLOTRO* as much as I want to. But with news that Amazon Games' attempt at making a Lord of the Rings MMO was now dead, it got me thinking about this 14-year-old game and the tiny community that's kept it quietly going for so long. It was time to try again.



Hobbit forming

After suffering through the age-old MMO problem of being forced to choose a class based on nothing but a paragraph of general description, I am ready to embark on my own journey through Middle-earth. Feeling nostalgic, I decided to play a hobbit Guardian, which means I specialise in wielding big shields and full plate armour. It doesn't sound very hobbit-like, but the in-game description tells me this class was inspired directly by Samwise Gamgee's stalwart devotion to Frodo. I guess the 200 pounds of plate mail I'm sporting is a metaphor for how ol' Sam had to carry Frodo's lazy ass halfway up a volcano. Share the load and all that.

Despite being such an old MMO, *The Lord of the Rings Online* surprises me with how involved its storytelling is. Instead of dropping me into the Shire and setting me loose, there's an hours-long prologue complete with cutscenes that immediately suck me into the fantasy of this world.

It's night time and I'm walking on one of the main roads through the Shire when I bump into a hobbit cop called a Bounder. He questions me about being out so late, but before long we're interrupted by some familiar faces: Frodo, Samwise, and Pippin. I realise immediately the significance of what is happening and can't help but smile. Frodo and company are just beginning their grand adventure, fleeing from the Shire while chased by Ringwraiths who have finally pinned down the location of Sauron's One Ring.

It's a classic scene from the books but with the twist of being able to spectate it as a bystander. Sensing danger, Frodo and crew have the good idea to ditch the main road and hoof it through the wilderness just as a Ringwraith comes galloping up. It interrogates me and the hobbit cop before taking off after its prey.

Paying the toll

If there's a clear strength to *TLOTRO*, it's that it colours in the missing pieces of the Fellowship's journey to destroy the One Ring. Before Aragorn sets off to join Frodo and Sam in Bree, we help him unravel a bandit conspiracy to destroy a village. I reunite a sheriff with his son and then fight in a dramatic showdown with the bandits. There's some real momentum to the story here, and then all of that grinds to a halt.

After finishing the prologue, I'm not immediately whisked off on my own epic adventure. Instead I'm dropped into Hobbiton and run face-first into that tedious MMO

Despite 14 year old graphics, Aragorn is surprisingly hunky.

grind. At this point, *TLOTRO*'s MMO roots trip me up as I come to realise the long road that awaits me. There's more cinematic story quests to experience, but they're now spread out and gated behind levels that I can only earn by doing much more menial chores. I putter around a bit, suddenly feeling overwhelmed by how my quest log has ballooned in size with mindless busywork and wondering if I'm really up to investing countless hours muscling through sidequests at the promise of being slowly drip-fed a 3D interpretation of Middle-earth.

On the level

I decide to Google how long it takes to reach max level. I'm not at all encouraged by Reddit responses like "I've been playing for eight years and I'm still only level 83 [of 130]". I'm sure that person is just taking their time, but the gravity of the investment required hits me.

It's not at all helped by *TLOTRO*'s messy approach to free-to-play either. Instead of keeping everything tied to its eight main expansions, Middle-earth is diced up into dozens of quest packs that are specific to certain zones. Features like certain races, classes, mounts, abilities, passive perks, and cosmetics litter the cash shop, making me feel overwhelmed.

Like a city built on the ruins of an old one, *The Lord of the Rings Online* feels haphazard and incongruous. And it adds so much unnecessary friction for newcomers like me who just want to get lost in this world. I desperately wish it had followed in the footsteps of other MMOs like *Star Wars: The Old Republic*, which long ago simplified everything by overhauling its quests so that players could focus entirely on the main story and forget the tedious grind.

To Bree

Feeling dejected, I'm about ready to give up. But that promise of Middle-earth and all its splendours is still too enticing for me to let go completely. I alt-tab out of the game and watch some videos to get a

LORD OF THE RINGS
The best PC games set in Middle-earth

MIDDLE-EARTH: SHADOW OF MORDOR
This standard action-RPG is renowned for its innovative Nemesis System that gives orcs dynamic personalities and special abilities that evolve each time you encounter them.

THE LORD OF THE RINGS: RETURN OF THE KING
This fairly simple action-RPG lets you play as different members of the Fellowship and masterfully recreates the chaos and scale of the third film's big battles.

THE LORD OF THE RINGS: THE BATTLE FOR MIDDLE-EARTH 2
Big battles defined the films, and *Battle for Middle-earth 2* turned them into an intense strategy game similar in many ways to the *Warhammer: Total War* series.

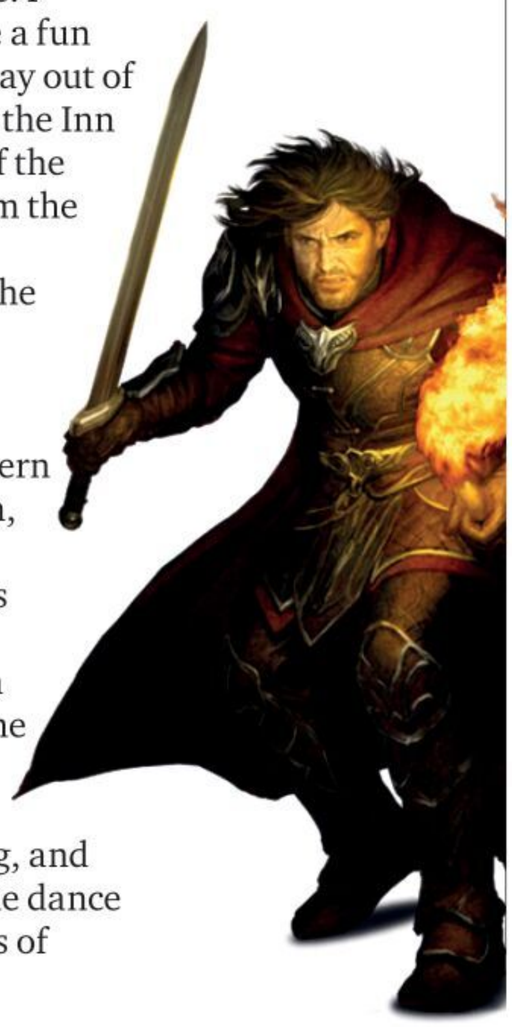
Troupes of player bards take turns playing music in Bree.

ABOVE: The Shire is as idyllic a place as ever. **RIGHT**: Players can compose music for several different instruments.

"Small bands are each taking turns playing tunes, and between each song the crowd erupts into applause as players light off fireworks that explode high above us."

taste of some of the different zones available in the games.

Wanting to see some of these places for myself, I decide to set out and go as far as the game will let me. Eventually some paywall will stop me, I figure, or monsters will become such a high level that survival becomes a statistical impossibility. So I do the most un-hobbit-like thing possible and leave the Shire behind me. I decide that Bree might be a fun village to stop at on my way out of dodge – if only just to see the Inn at the Prancy Pony, one of the more iconic locations from the first film.



I arrive in Bree just as the sun has set. I wander the streets, looking for this famous inn and find it tucked into the northeastern corner of the walled town, but before I can even set foot inside my attention is stolen by something altogether remarkable. In the square right next to the inn, dozens of players of all levels have gathered and are dancing, shouting, and cheering. Surrounding the dance floor are different troupes of bards. It hits me: this is a music festival.

Music to my ears

I knew *TLOTRO* had a system where players could play instruments, but I'd never seen it in action. These small bands are each taking turns playing tunes, and between each song the crowd erupts into applause as players light off fireworks that explode high above us. Until now, I had seen a few players as I wandered around the Shire, but now I am surrounded by several dozen.

Seeing another hobbit in the crowd named Tiddley, I send her a private message on a whim. She tells me she's been playing for a decade. "I love the lore of the game," she says. "And there's always something to do. Be it raiding, dancing, playing music, fishing, or decorating the house."

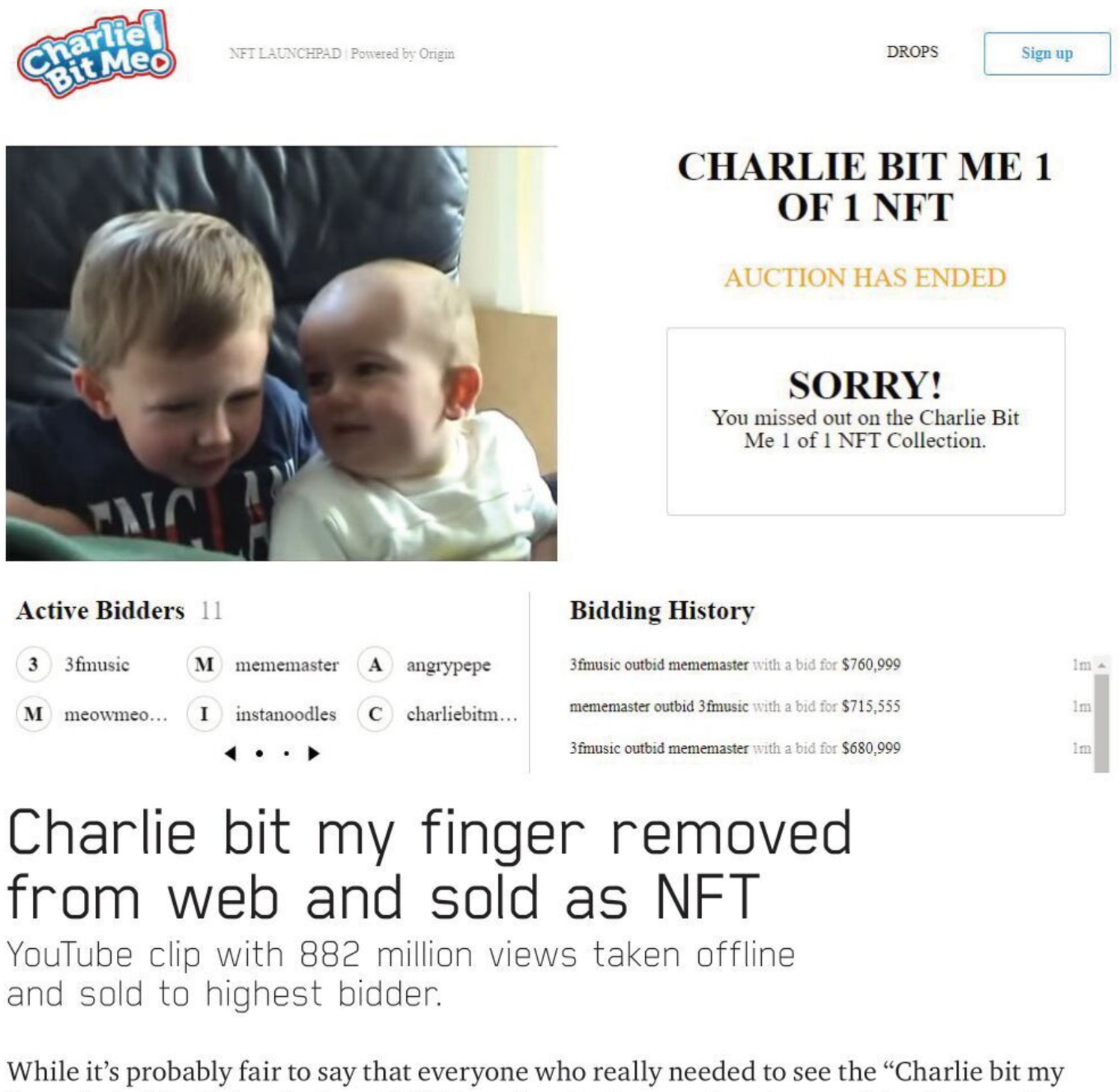
We chat for a bit and she talks about how great *TLOTRO*'s community is. "Most of the people that play are very helpful if you have a question or need help with a quest or something crafted," Tiddley says.

Our conversation leaves me feeling even more conflicted than I was before. I was ready to give up on *TLOTRO* for good, thinking that whatever potential was there is now buried under microtransactions and grinding. But seeing how tightly knit its community still is tells me I'm missing something, and it eats at me.

I watch the bards take turns playing for a while longer, wishing I saw in this MMO what others do. I'm envious of these players and the connection they must have with this world, but I just can't imagine spending hundreds of hours of my life in an MMO so deeply in its twilight years. *The Lord of the Rings Online* must've been a special game to have kept people like Tiddley playing for so many years, but it's hard to see that magic today. ■

CHIP CHAT

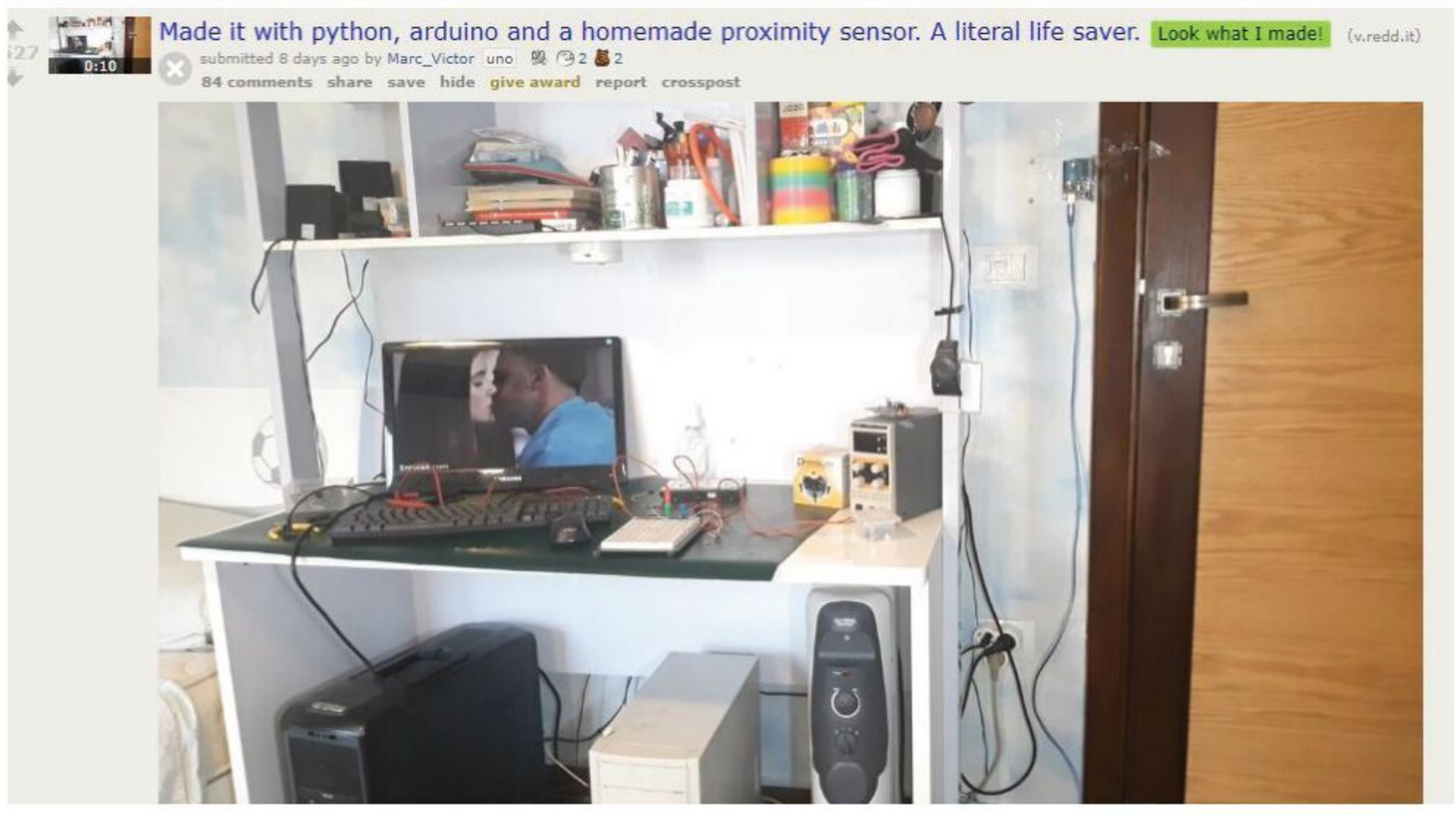
JOEL BURGESS REPORTS ON THE UNUSUAL SIDE OF TECH NEWS



Charlie bit my finger removed from web and sold as NFT

YouTube clip with 882 million views taken offline and sold to highest bidder.

While it's probably fair to say that everyone who really needed to see the "Charlie bit my finger" viral YouTube clip from 2007, has already done so, there's something inherently upsetting about the concept of forcibly removing it from the internet so it can be sold to one individual for a private collection. Yet this is the fate for many pieces of web culture as the NFT boom continues to expand into unexpected places. If this seems ridiculous, we're with you, but 11 active bidders scrambled for the video that eventually sold for US$760,999.



DIY Arduino Alt Tab contraption

For Alt Tabbing when your hands are full.

Anyone who's ever looked at something on a computer that they didn't want to get caught looking at knows the Alt Tab shortcut, but instead of using the keyboard for this switch program command, one Reddit user, Marc_Victor, has designed an Arduino contraption that'll do it for him. The Arduino-based proximity sensor connects a bedroom door trigger to a keyboard, allowing it to automatically pull up a file index folder in front of whatever was on screen.

Texas energy company turns off customers' air conditioning when it's hot to save energy

EnergyHub REMOTELY changes customers' thermostats at peak times.

Instead of fixing the electrical infrastructure that led to blackouts across the state of Texas at the start of 2021, it seems the region is utilising the services of a company called EnergyHub that remotely changes the temperature of customers thermostats during periods of peak energy demand. In exchange for having your air conditioning cut out without warning at the most inconvenient times, customers are entered into a sweepstakes where they can win prizes. Since not having your family suffer through dangerous heat levels at home is the best prize anyone could ask for, we're not sure the 'Smart Savers Texas' program will last long.

Engineer designs self riding bicycle

ONE MAN MADE A FULLY AUTONOMOUS BIKE IN HIS SPARE TIME.

Google's 2016 April Fools joke of a video showing a self-driving bicycle seems to have inspired Chinese Engineer Zhi Hui Jun to spend the next five years of weekends and spare time bringing the concept to life. The autonomous bicycle invention uses a clever spinning motor to keep the bike upright, a second to push it forward or back, and a third to turn the handlebars. The series of motors are controlled by an onboard system running custom software that collects information from an RGBD (depth) camera, an accelerometer, a gyroscope and LiDAR to detect objects and allows it to navigate to the desired destination. ■

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