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4K RYZEN PC BUILD

STEP-BY-STEP GUIDE
Craft this 4K gaming PC **PG. 16**

✚ **Forge the best bang-for-buck PC in 2023**

✚ **Use AMD's new 7950X CPU and 7900XT GPU**

✚ **Intel & Nvidia level performance for less**

RAIDERS OF THE LOST ARC

VOL 28, NO 4

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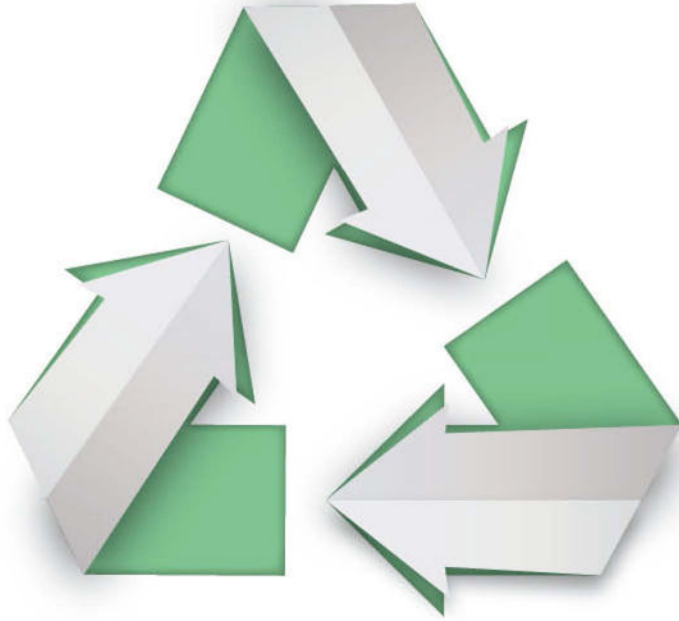
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inside

APRIL 2023

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MAXIMUMPC

Guy Cocker

TIME FOR TEAM RED

WE PROMISE it's nothing personal, but we've been maligning AMD and its GPUs for the past six issues. True, it's mainly because Nvidia has been drip-feeding its Lovelace-powered 4000-series cards to market, starting with the flagship 4090 and then running down to last issue's 4070Ti build. Nvidia is also the undisputed king when it comes to discrete GPUs, claiming 88 percent of the market in Q3 2022.

But we don't need to tell you that there's been a collective sigh when it comes to Nvidia's pricing this generation, with the RTX 4080 ($1,199) being a particular disappointment in the price-to-performance department. With AMD's RX 7900 XT being cheaper than the RTX 4080, but promising similar performance, is it time for people to ditch Team Green and head over to the relative value offered by Team Red?

That's the question we posed to our builder Sam Lewis this month, as he builds our first all-AMD system of the year. He's gone big, pairing it with a kick-ass AMD Ryzen 9 7900X CPU, DDR5 RAM, and a brand new NZXT H9 Flow case, all for just over $2,900. OK, that's not budget territory, but it's pretty reasonable in these highly-inflated times. So how does it stack up to an equivalent Intel/Nvidia system? Is AMD the smart choice for both CPU and GPU price-to-performance in 2023? Sam breaks it down starting on page 16.

If you've been reading our letters pages of late, you'll know we've had lots of comments about our *Blueprints* section, which we update every issue. We'd always modeled these spec sheets based on 1080p, 1440p, and 4K gaming, with Budget, Mid-Range, and Turbo monikers respectively. The feedback we got was that our budget builds weren't actually very budget anymore, with prices that had crept up thanks to scalpers and manufacturers over the past couple of years. We've adjusted the specs to get them back under $1,000 but have decided to keep the GPUs in there, based on your feedback. Read more on page 94.

We've also got a couple of great features in this issue, each with a cost-saving focus. The first is a feature from our resident Doctor, Nick Peers, on reusing and re-purposing old tech that might be gathering dust in your home. Whether it's an old computer you could convert into a server or a tablet you could turn into a digital photo frame, there are loads of great tips on page 32. And, on page 42, we show you how to erase all of your private data, whether that's files that aren't actually deleted from your PC, or the passwords and credit card info that gets stored across all your devices.

I mentioned that we were Team Red for this issue, but there's still lots of Intel within these pages. We have a review of the 6GHz i9-13900KS, the powerhouse processor perfect for overclockers. We also have a review of the Intel Arc A770 8GB, while Jarred Walton has penned a feature on the improving driver situation for Intel's graphics cards. After a rocky start and a generation of sub-par products, there's a feeling that (whisper it!) Intel could slowly be turning itself into a contender in the GPU space. In fact, it might not be long before you see an all-Intel build adorning a *Maximum PC* cover.

Enjoy the issue!

Guy Cocker

Guy is Maximum PC's Editor-in-Chief. He built his first gaming PC in 1997 to play Tomb Raider *on 3dfx, and has been obsessed with all things PC ever since.*

↘ submit your questions to: editor@maximumpc.com

THE NEWS

AMD's Fastest Yet

16 cores and 144MB of L2 cache on a desktop processor

AT THIS YEAR'S Consumer Electronics Show, AMD's Lisa Su made the usual slew of announcements, but the most anticipated was the official launch of its new Zen 4 V-cache chips. These are expected to be gaming monsters. Selling the best gaming chip is a hotly contested achievement that has flipped between AMD and Intel. On release, AMD's V-cache chip, the Zen 3 Ryzen 7 5800X3D, immediately took the title, a feat AMD is keen to repeat with its more powerful Zen 4 versions.

There are three offerings, the Ryzen 7 7800X3D ($449), the Ryzen 9 7900X3D ($599), and the Ryzen 9 7950X3D ($699). The 7800X3D has eight cores, a boost of 5GHz, and 104MB of L2. The 7900X3D has 12 cores, a boost of 5.6GHz, and 140MB of L2. The 7950X3D has the full 16 cores, a boost of 5.7GHz, and 144MB of L2. The two bigger chips are available now, with 7800X3D following in April. They're unlocked for memory and infinity fabric overclocking, and you can also play with the Precision Boost Overdrive and Curve Optimizer settings. The core voltages and multiplier aren't unlocked, so no old-school overclocking.

Lisa Su made some bold claims about AMD's CPUs, but the new Zen 4s are gaming monsters.

AMD also has a few figures to impress. The Ryzen 9 7900X3D is said to be 15 percent faster on a selection of games than the old Ryzen 7 5800X3D. It also has figures pitting a 7950X3D against Intel's finest, the i9-13900K, and, according to Dr. Su, it can "consistently deliver" higher frame rates than its rival. Leaked benchmarks from early samples appear to bear this out, and AMD appears to be king again. Early tests put it about six percent ahead of team blue over a selection of 22 games. On multi-threaded benchmarks it does even better, depending on the benchmark used.

There is a downside to adding a layer of cache, and that's heat. That extra layer between the processor and cooler makes a difference, which explains the lower base clocks. The 7950X3D has a base clock of 4.2GHz, against the regular 7950X's 4.5GHz.

This has led to an oddity. It appears that the 7950X3D is slower than the regular 7950X when it comes to benchmarks such as Geekbench and Blender, which don't suit its hardware configuration. This has been put down to the V-cache speeds topping out before reaching theoretical maximums. It seems the 7950X3D isn't the chip to dominate every benchmark.

There's speculation that the 7800X3D could be faster than its sibling at some tasks if it has the thermal room to effectively run at faster clocks, specifically on that extra cache. We won't know until all three have been compared, which is annoying if you're itching to buy one. There was a similar situation when the original V-cache chip

appeared—it proved slower than the regular 5800X on single-thread tasks, but shone when given room to breathe on cache-heavy applications.

AMD's new Dragon Range has also landed in laptops—the first Zen 4-based mobile chips and the first to feature a chiplet design. These stick to the older RDNA 2 architecture for graphics, however, gaming laptops will be running discrete GPUs anyway. AMD's promotional slide for the new chips says "Absolute mobile supremacy for gamers and creators". Quite a boast. The fastest chip is the Ryzen 9 7845HX which has 12 cores, a base clock of 3GHz, and a maximum boost of 5.2GHz. The first tests pitched it against Intel's Core i9-12900HK, and it proved itself more than a match until Intel released even faster mobile chips (see page 10). AMD has the 16-core Ryzen 9 7945HX to come, which has yet to reach laptops, so the contest isn't over yet.

Competition has stopped Intel from selling its finest at a premium, something it did when it had a clear lead. You can find the i9-13900K for $570 or less. AMD has dropped the price of its regular 7000-series chips to make room for the X3D versions, the Ryzen 9 7900X is officially $449, and the 7950X is $599, with both available for less. We'll be taking a fuller look at AMD's new cache-rich chips as soon as we are able to test them over a selection of triple-A games. **–CL**

> ❝ It seems that the 7950X3D isn't the chip to dominate every benchmark going.

© AMD

PC SALES SLUMP
PC INDUSTRY EXPERIENCES HUGE DROP IN UNIT SALES

FIGURES DURING the first flush of the pandemic were up by as much as 26 percent. The year after saw a small rise, but 2022 saw those gains come crashing back down. Some analysts claim it's the biggest such decline in the history of the x86 market, with year-on-year shipments of processors down by 21 percent from 2022. PC shipments fell by 28 percent in the last quarter of 2022, which is 67 million fewer systems. Is this actually bad news? Not really. The pandemic spike couldn't last, especially with the production problems it created. This year's figures are expected to level out by the second half of the year and to have returned to a level we might have expected if the pandemic hadn't happened at all by the end of the year. The business market, which has delayed many PC purchases, is expected to return fully by 2024. **–CL**

WINDOWS ON AN APPLE
Getting Windows running on an Apple Mac has never been simple

THIRD-PARTY applications have had various degrees of success. Parallel Desktop for Mac appeared back in 2006 and runs Windows as a virtual machine rather than as an emulation. Previously you were on your own, but the latest version has gained official approval from Apple.

There are some notable limits, though. No 32-bit apps, no DirectX12 or OpenGL3.3 either. You can't add another layer of visualization either, so no Linux or Android sub-systems. As a gaming platform, it's a dud. For a single user, it's not particularly affordable either, as licenses start at $100 for home use. However, it is cheaper and much more convenient than buying a whole new rig just to run an important Windows application or two. Parallel claims it has seven million customers, so it's not an uncommon scenario. **–CL**

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

TRIUMPHS

✓ **VALUABLE VOODOO**
An engineering sample of the 3dfx Voodoo 5 6000 card fetched $15,000 at auction.

✓ **CUT THE BLOAT**
Tiny11 is an unofficial Win11 installation that removes its hardware requirements. It needs 8GB of storage and 2GB of RAM.

✓ **STACKED SCREENS**
MIT researchers have made an ultra-thin membrane that stacks red, green, and blue microLEDs to increase pixel density.

TRAGEDIES

✗ **MILITARY BLUNDER**
A Pentagon server was left unguarded for two weeks, leaving millions of sensitive Defense Dept emails exposed.

✗ **MASSIVE RECALL**
Tesla has had to recall 362,758 vehicles after an assessment by the National Highway Traffic Safety Administration.

✗ **JUNK PROBLEM**
Outlook has been filling some inboxes with junk and spam. Deactivation is the only cure.

RTX 4070 THIS APRIL
4060 to follow, as 40 series goes mainstream

SOME OF THE first outsiders to know about new cards from Nvidia are its partners, and the company has given notice that it is to launch the GeForce RTX 4070 in April. It will be the lowest-spec desktop version of its new Ada Lovelace architecture yet. Details are to be confirmed, but the 4070 will use the same GPU as the 4070 Ti, the AD104, but cut to 5,888 CUDA cores. If correct, it's quite a drop as the Ti has 7,680 cores. It means yields on the wafers should be near 100 percent though. It'll also have 12GB of memory on a 192-bit bus, but availability and pricing will depend on how many unsold 30-series cards there are.

Next on the schedule will be the RTX 4060 Ti. This is expected to sport an AD106 GPU with 4,352 CUDA cores coupled to 8GB of GDRR6 memory. Another step down will be the RTX 4060, which could use the AD107 GPU—the same chip used in the RTX 4060 Mobile, which appeared weeks ago. This has 3,072 CUDA cores, 24 ray-tracing cores, and 8GB of memory on a 128-bit bus. If this pans out, it looks disappointing. Previous generations of Nvidia cards have used different chips in the desktop and mobile versions. That's a narrower memory bus and fewer CUDA cores than the RTX 3060 it replaces. Nvidia needs to pitch this card right. We expect announcements on both 4060s in the next few weeks, with cards due before summer.

Meanwhile, we have another tantalizing prospect: an RTX 4090 Ti. The current RTX 4090 uses the biggest GPU die, the AD102, but leaves 16 streaming multiprocessors, and a quarter of the L2 cache out. AD102 GPUs exist with 18,432 cores, so Nvidia has the headroom to build an outrageous card. Power consumption is one problem, rumors of 600W cards are frightening. Fun as though the 4090 Ti will be, what the market needs is solid mid-range kit. **–CL**

Graphics card prices are still too high. What we need is decent affordable mid-range kit.

CHATBOT WARS

Microsoft and Google square-up over AI

A MERE MONTH after investing $10 billion in OpenAI—the developer of DALL-E and ChatGPT—Microsoft has added an AI chatbot to Bing and has plans to add it to a Sidebar in its Edge browser too. Currently, the new AI Bing is available as a limited preview, which illustrates it at work on a dozen example questions. You can also join a waiting list for fuller access.

It can write poems, help plan holidays, write code, and make a pretty good attempt at intelligent conversation. It's eerie. The Bing version has been customized for search results, enabling you to easily refine your criteria, saving you from wading through too many answers.

Since this is an AI chatbot on the Internet, obviously some people tried to make it spiral into disturbing or confusing replies. Previous chatbots have proven fragile in this regard. When pushed, things can get bizarre, from insisting that the year is 2022, to getting unduly personal or expressing unsettling desires. Microsoft was forced to limit the number of questions on a topic, as the more there are, the further things can spiral.

Naturally, Google didn't take long to announce it had launched a rival called Bard, which it had been working on for years. The public reveal of Bard by Google's CEO, Sundar Pichai, was rushed and contained an embarrassing error when it managed to get an easily-verifiable fact wrong. Bard has been made available to 'trusted testers' and is expected to reach the general public in a few weeks.

It seems Google wasn't in any hurry until ChatGPT hit the headlines, and is now trying to keep up. We have an AI arms race brewing. It's a field that's developing fast and has many other applications. Like it or not, we're going to be spending much more time talking to machines. **–CL**

Intel's mobile monster

AMD'S NEW DRAGON RANGE has been outclassed a week after its launch by Intel's i9-13980HX and 13900HX, both destined for power-mad gaming laptops. Both use eight P-cores and 16 E-cores, so we have 32 threads in a laptop for the first time. The 13980HX can buzz along at a maximum boost of 5.6GHz, while the 13900HX is 200MHz behind and has 100MHz slower E-cores. Otherwise, the 55W chips are the same, and even have the same price: $668. These prove to be about 10 to 15 percent faster than AMD's best. Only the forthcoming 16-core Ryzen 9 7945HX could rival these.

Intel also has two new F-series Raptor Lake chips—a Core i7-13790F ($441) and an i5-13490F ($235), with the 'F' denoting the lack of an integrated graphics engine. The i7-13790F follows the pattern of the i7-13700: with eight P-cores, and eight E-cores, running at 4.1GHz and 1.4GHz respectively. The E-cores get a 100MHz bump, plus there's an extra 3MB of L3 cache. The i5-13490F effectively replaces the i5-12460F and has six P-cores and four E-cores. Clock speeds are 3.5GHz and 1.8GHz respectively. These should be effective gaming chips, but they are initially destined for the Chinese market. Also arriving this month is a range of six low-power 'T' series chips with a TDP of 35W, the lowest power consumption Raptor Lake chips available.

Meanwhile, we say goodbye to Rocket Lake as production ends. It was a 14nm process chip, basically a back-port of a 10nm design due to production problems. Intel has come a long way since, though there has been one slight wobble. It had planned to employ TSMC's 3nm process for its GPU tiles on Arrow Lake but has ditched the idea. The N3 silicon is in high demand and Apple has just bought TSMC's entire first batch—pushing Arrow Lake, which was set to appear early next year, back a few months. **–CL**
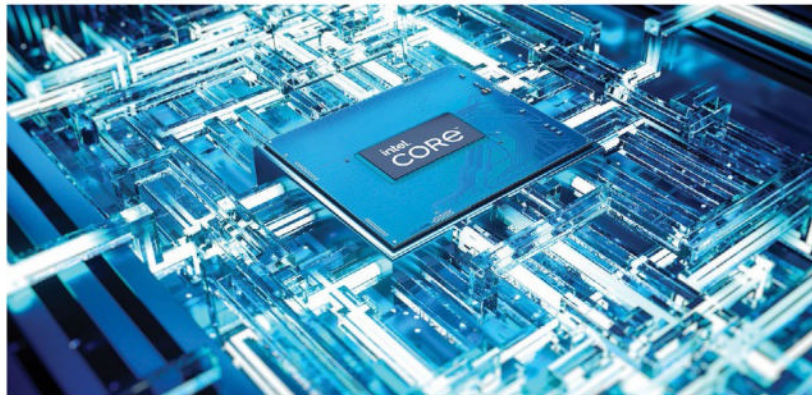
Activision sale

Microsoft wants to buy Activation for its wealth of game franchises, from *Call of Duty* to *StarCraft* and *World of Warcraft* in a deal set to cost $68.7 billion. Legislators here and abroad started taking a closer look at the ramifications, calling for a halt to proceedings over concerns about fair competition.

The deal would make Microsoft the world's third-largest gaming outfit and the biggest in the US. Hurdles include legal action by the Federal Trade Commission and gaming groups, and complaints from Sony. It has gathered support, including cutting deals with Nvidia and Nintendo to keep its games on its platforms. Legal experts are divided as to which way this one will go. **–CL**

44TB of My Book

Western Digital has launched its highest capacity consumer drives: new 22TB and 44TB versions of its My Book external drives. This is a logical extension of the My Book range using WD's latest 22TB HDDs. My Book supports 256-bit hardware encryption, has built-in password protection, and passes data around using USB 3.2 Gen 1.

The 44TB Duo model, as you might have guessed, has two 22TB drives. It comes configured as a RAID 0 array, giving you the whole 44TB down one USB cable. Alternatively, you can configure the drive as RAID 1, in which the drives mirror each other, halving the capacity but offering data security. The 22TB version is $600, and the 44TB Duo is $1,500. **–CL**

Jarred Walton

TECH TALK

The Meteoric Rise of ChatGPT

DEEP LEARNING, artificial intelligence, and large language models (LLMs) aren't entirely new—we've been hearing about them for years in various forms. But 2023 could mark the tipping point where things truly go mainstream, after a company called OpenAI shook the foundations of multiple industries by releasing its ChatGPT tool to the public.

Earlier this year, OpenAI previewed and then eventually provided public access to its text-to-image Dall-E 2 tool. To say that people have taken note would be an understatement. In just two months since its launch, ChatGPT has reached over 100 million users. That's the fastest ramp in users of any internet app, with Tiktok coming in second at nine months, while Instagram required two and a half years to reach that number. People are asking it for advice, letting it write essays and poetry, asking it to tell jokes, and attempting to play text-based games (though it cheats at *Hangman*).

In February, Microsoft announced an updated version of its Bing search engine, with a customized ChatGPT-powered 'chat' function codenamed Sydney and Google revealed its rival Apprentice Bard AI. Where Microsoft opened the doors to public access (with a waitlist that prioritizes users with Edge as their default browser), Bard isn't available to the public. Given what we've seen from Bing, though, that might be for the best.

Bing Chat perhaps had too much personality, expressing emotions including love, anger, and insecurity. Cue the "I've been a good Bing Chat. You've been a bad user" memes—yes, it actually used that line. Microsoft apparently didn't learn the lessons from its aborted Tay chatbot, but was quick to nix some of Sydney's behavior—I'd argue that it was more entertaining when it had emotions.

> **Ask ChatGPT to build a PC and it spits out a step-by-step guide to a non-functional system.**

The problems with ChatGPT, Bing Chat, and similar tools aren't limited to personality, however. Asking ChatGPT for advice on how to build a PC yields some seemingly reasonable advice, except it clearly lacks experience in building PCs and instead spits out a step-by-step guide that is likely to result in a non-functional system and potentially broken or incompatible parts. ChatGPT notes that it can provide factually wrong information, but only someone educated in a topic is likely to notice.

In related news, C|Net and several other sites owned by publisher Red Ventures started posting AI-generated content and using AI to update articles. It didn't take long for people to begin noticing errors. The practice was halted, but further details have emerged, including internal memos expressing concerns that Google would detect and penalize sites for such content. Analysis of the published articles also showed that whatever tool Red Ventures created was more than happy to plagiarize content from rivals.

But ChatGPT and similar tools aren't going away. The current version is GPT-3, a third-gen 'Generative Pre-trained Transformer', but GPT-4 is already in development, which should

ChatGPT and other AI tools already offer impressive results—and they're only going to get better.

provide improved results and performance on a similar data set to GPT-3. There's a race to see who can successfully deploy LLMs and capture more of a potentially lucrative market.

We're not yet at the point where you can run your own ChatGPT instance, as the model requires around 800GB of memory. That's a big jump from the 4-8GB needed to run Stable Diffusion, an open-source AI tool for generating images from text descriptions. But with free public access to ChatGPT and Bing Chat, that may not matter.

Thankfully, other tools are being created to combat the use of ChatGPT. That's good news for educators, who might otherwise be hard-pressed to determine whether students are doing their homework or leveraging an AI. GPTZero.me can help determine the likelihood of something having been generated by ChatGPT. This article checks out as "most likely human written", which is good, as it means I'm not yet out of a job.

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

THE LIST

THE TOP FIVE PC FANS

WHEN BUILDING A RIG, it can be tempting to use your case fans and leave it at that. But if you're maxing out your graphics card and CPU, it pays to spend a little more attention on the airflow. Cool hardware is essential for optimal PC use and good PC fans are so important we often recommend checking the fans first in the event of any issues. So, if you want the best fans for your PC, we've listed five of our favorite options below.

5

NZXT AER RGB 2 120MM

NZXT makes gorgeous hardware—not always the cheapest or the most efficient—but certainly great to look at. Even at low speeds, this is louder than other fans here—that's why it isn't higher on the list—but look at it! Sure, it's RGB, but also somehow a bit sleeker and more refined than other flashy fans. The Hue 2 controller is more attractive than any of the other boxes we looked at too. **www.nzxt.com, $30**

4

COOLER MASTER MF120R A-RGB

Cooler Master's RGB design features only fan blade lighting instead of a ring around the outside, but it's attractive, bright, and has smooth transitions. But there's a catch—they're loud at the maximum 2,000rpm speed. Of course, they move a lot of air through your system, but you'll want to limit them to running at 1,200 or 1,500rpm. Thankfully, the high-value price still means they warrant a closer look. **www.coolermaster.com, $20**

3

NOCTUA NF-A12X25 PWM

If you're a PC hardware enthusiast, you'll respect anyone who uses Noctua's khaki-and-mud colored components, even if they do give your build something of a retro look. On the plus side, this fan is the quietest we tested and it also pumped the most air through our test rig. The price is high but the performance is magical, meaning it's the best pick for those who want to push their fans hard. **www.noctua.at $30**

2

CORSAIR LL120 RGB

If you're after that cyberpunk aesthetic, Corsair's LL120 Pro RGB fans are the best around. They're the brightest fans we tested and a perfect fit for any RGB addict. At mid-range speeds, they're slightly louder than the competition but, at load, they're quieter than just about any non-Noctua fan we tested. They're expensive though, with a pack of three costing $120. **www.corsair.com, $40**

1

NOCTUA NF-S12B REDUX-1200

If you care about case fans, you'll already know the name Noctua. The company's Redux line upgrades the old brown colored units with a modern gray-and-black look that won't detract from the rest of your PC build. It's not as quiet or efficient as another blacked-out model, the NF-S12A, but it is cheaper. The NF-S12B Redux-1200 balances great performance with a budget-friendly price tag—and it looks great too. **www.noctua.at, $15**

Jeremy Laird

TRADE CHAT

It hurts to admit it, but Nvidia is good for the PC

HOW MUCH LONGER will this ludicrous graphics card pricing last? I believe that an adjustment will happen, eventually, but is Nvidia to blame and do silly GPU prices prove that the company is a malign influence? The answers to those questions are yes and, surprisingly, no. The company is no angel. But the PC is still better off with Nvidia.

Here's the thing. Nvidia is pathologically pushy, for better and for worse. The same mindset that drives the company forward with aggressive, relentless innovation is also at the root of Nvidia's occasionally questionable commercial policies and prickly interactions with outside observers.

On the one hand, you have Nvidia's technical might and its passion for pushing forward with new technology. Take DLSS, or Deep Learning Super Sampling. When it was first mooted back in 2018, it looked like tech straight out of the classic Nvidia playbook—proprietary, superficially seductive but, ultimately, of dubious real-world value.

Upscaling tech that looks as good as native rendering but runs faster, enabled by some secret AI-enhanced snake oil? Give me a break. Except, DLSS has evolved into a fantastic technology and has made upscaling an essential part of the GPU feature set. And with DLSS 3 and its clever frame generation, Nvidia has moved the game on further. Its main rival AMD is in constant catch-up mode.

Then there's ray tracing. When the first ray-tracing-enabled GPUs debuted with the RTX 20 series, it looked like another questionable technology locked down to Nvidia hardware and barely relevant to actual gaming. Hardly any titles supported it, those that did barely used it, the performance was terrible and you were doing well to spot the difference it made to rendering quality.

But three generations of RTX GPUs on, AMD and Intel are fully committed to ray tracing. While it still

doesn't make a huge difference to the way games look, few doubt that ray tracing will replace rasterization as the dominant technique for rendering lighting in 3D game engines. More to the point, without Nvidia as a driving force, ray tracing would barely be a thing at all on the PC.

There is of course the other hand, the shadier and more malign yin to Nvidia's innovation yang. Over the years, Nvidia's influence over game development, its attempts to align game engines with its own hardware rather than targeting the best performance and quality regardless of GPU vendor choice, has arguably been to the detriment of the PC as a whole.

Nvidia's relationships with companies, known fancifully as partners, haven't always been healthy. The company was forced to shut down its controversial stick-and-carrot GeForce Partner Program in 2018 to put an end to what Nvidia described as the "rumors, conjecture, and mistruths" around the program.

Then there's the way Nvidia has sandbagged certain GPU generations, especially when the AMD competition failed to turn up. How much faster would PC graphics be if Nvidia made the best products possible rather than the minimum needed to maintain its

It's sometimes hard to separate Nvidia the company from its iconic CEO Jen-Hsun Huang.
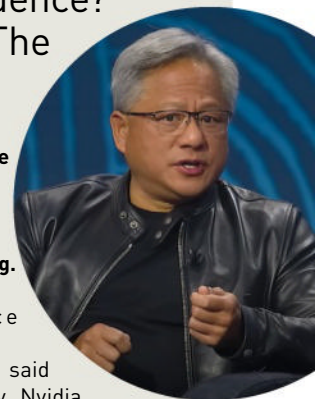
performance advantage?

The less said about the way Nvidia throws its toys about when a media outlet dares to contradict its favored narrative the better. Banning YouTube channels from its review cycle isn't a good look.

Right now, product pricing is admittedly making it hard to remember all the good things that Nvidia has done for PC graphics. But as offensive as an RTX 4080 graphics card from Nvidia is for $1,200, and as frustrating as it is to know how good its latest RTX 40 generation of GPUs could be in general if only they were priced sensibly, the positives Nvidia has brought to PC gaming over the years still far outweigh the negatives. It doesn't always feel like that, but the truth is that, as PC enthusiasts, we're all better off thanks to Nvidia.

Six raw 4K panels for breakfast, laced with extract of x86... Jeremy Laird eats and breathes PC technology.

> **The positives Nvidia has brought to PC gaming still far outweigh the negatives.**

DOCTOR

> ## TPM and Win11
> ## Audiophile PCs
> ## New mobo issues

Reducing signal noise is vital for sound quality.

TPM chip needed?

I have two i7 computers that fail the Microsoft Windows 11 requirements test: the problem is TPM and Secure Boot. I am starting to look at motherboards for an i9 build next year. From what I've seen so far, none come with TPM, but all say they are capable of running Windows 11. I notice in your *Blueprints* section, the build says "Windows 11 Compatible" but makes no mention of TPM. I also see in your October i5 build, it used the Win 11 OS, but again no mention of TPM.

Are we in a situation of having to buy a TPM card if we want Windows 11? Why aren't manufacturers including TPM? Is it safe to assume all recent mobos include Secure Boot?

—John Reilly

THE DOCTOR RESPONDS: If your processor meets the minimum requirements for Windows 11, then there's no need to buy a TPM card for your motherboard, John. Modern Intel and AMD CPUs—specifically those built after 2014—come with TPM embedded into their firmware; however, only later CPUs, from around 2017, support TPM 2.0, which is the minimum requirement for Windows 11. You can view a definitive list of CPUs supported by Windows 11 at (https://learn.microsoft.com/en-us/windows-hardware/design/minimum/supported/windows-11-supported-intel-processors)—all of these will work without the need to worry about TPM support on the motherboard.

As you're building a new PC, make sure you choose a CPU from this list—any i9 CPU from 2017 onwards (so i9-7900X series and up) is supported. As for Secure Boot, all recent motherboards support it—including those that are Windows 11 compatible.

Audiophile PC build

I am a long-time subscriber, and this is a follow-up question I had earlier this year ("One for audio files...", Feb issue).

The main issue with building a media computer is getting high-resolution, audiophile-quality sound from a PC. My receiver (Pioneer Elite SC-68) has a reasonable quality asynchronous USB DAC input port, so I don't need a separate external DAC unless I wanted to use a high-end DAC. Either way, the audio connection from the computer to the DAC (external or the one in the SC-68) would be through a USB connection.

However, the audio from a computer is not as good quality as it needs to be. It's my understanding that most motherboards (or sound or video cards) do not provide high-end audio, which is why media computers such as the ones from Baetis use their own daughter card just for the audio. They also have boards to improve on other things such as the USB.

What would you recommend for a high-end audio computer build that can come reasonably close to something like a Baetis media computer? **—John**

THE DOCTOR RESPONDS: You're probably already better versed than the Doc in these matters, John—his idea of top-quality audio is streaming FLAC music over Wi-Fi to a Raspberry Pi Zero sporting a now-discontinued 24-bit/192kHz Pi-DACZero connected to his 30-year-old Pioneer stereo. It sounds great to him, but in the absence of such expert knowledge, he will instead draw on his research skills to hopefully steer you in a useful direction.

First, a quick read of Baetis's many white papers reveals its top-end PCs avoid using the PCI bus for both its daughter cards and USB ports to minimize signal noise. As your DAC is capable of playing most audio formats directly from your PC, you could technically retrofit an existing PC with audiophile-friendly USB ports to deliver the music straight to your DAC. When it comes to USB, Baetis uses SOtM (https://sotm-audio.com) ports, which you could replicate by investing $350 plus taxes

into its tx-USBhubIN card. This connects directly to an internal USB header on your motherboard to bypass the PCI bus.

Dig a little deeper into the SOtM website, however, and you'll discover the company goes one step further, offering full-blown Intel motherboards optimized for audiophile use. Prices start from $550 for the sMB-Q370, which you would then augment with the tx-USBhubIN card and an optional Ethernet card if you decided to go down the server route (this would enable you to offload your music to a PC dedicated to the task).

Another key issue is 'noise' from your computer through its fans and PSU. Audiophiles recommend BeQuiet's range of quiet CPU fans—the Dark Rock 4 (www.bequiet.com/en/cpucooler/1376) can be had for around $75 online—as well as the HDPLEX Linear Power Supply range (https://hdplex.com), which cost significantly more (around $500) and are recommended by Baetis itself as an upgrade to its own PSUs. By now, you can see that the costs of building your own audiophile PC to rival the Baetis are starting to mount.

Generally speaking, the Doc would suggest you comb through the Baetis white papers with a fine tooth comb, making a note of any references to manufacturers like SOtM. Then, visit the manufacturer directly to see what's available before Googling the model name and 'review' to see what others make of it. This in turn will reveal useful resources like Audiophile Style (https://audiophilestyle.com/), which carries a review of the sMB-Q370 motherboard and offers forums where you can converse with like-minded enthusiasts who will be able to offer you more nuanced expert advice.

Split apps from Windows?

I've been a subscriber for ages and love your magazine. A few years ago, I followed your instructions for setting up the operating system on one drive, programs on a different drive, and data on yet another drive, possibly using partitions. I can't find the issue with those instructions, but it was one of the best-running systems I've ever owned.

I have searched for guides on installing Windows 11 in a setup where programs and data are automatically stored on different drives, with drive C maintained solely for Windows. Is that a good idea and, if so, can you tell me how to install Windows that way? **—Robert Kent**

THE DOCTOR RESPONDS: The Doc has long been an advocate of separating data from Windows and your apps, that way, if your Windows installation corrupts, your data remains easily accessible. But he's never been a fan of separating Windows from installed programs. The simple reason is that programs are so tied into Windows that if your Windows installation goes down so, too, will your programs, regardless of where you store them.

The Doc recommends storing portable apps on a separate drive—again, like your data, they aren't tied into your Windows installation and can be reused with no problems in a brand-new install. But as far as installed programs go, unless you're running Windows from a small boot drive and are running out of space, there's no good reason to split them off.

If you find yourself running out of space, consider a program such as SteamMover (www.traynier.com/software/steammover) to move apps to another drive on an ad-hoc basis.

Finally, whether you split data and Windows/apps on the same drive through partitioning or store them on separate physical drives, neither option is an excuse not to keep an additional backup of both in a secure location such as a NAS or encrypted cloud storage.

Wot, no 16-bit support?

Long-time reader, first-time writer. I just bought a new Dell desktop and it came with Windows 11 as an OS. Boy, has it been a struggle going from Windows 7! One of my main problems is that I cannot even install my legacy 16-bit programs. My studies indicate that it was possible in Win 10, but never in the latest version of 11. I certainly won't be renting Microsoft Office or paying an enormous price for Adobe Photoshop. There must be a way around this that doesn't preferably involve sandboxes. **— Frank Tushoph**

THE DOCTOR RESPONDS: The reason you can't run 16-bit apps in Windows 11 is that it's now a 64-bit-only OS. The workaround in Windows 10—enabling NTVDM support under Legacy in the Windows Features control panel—only worked with 32-bit versions of the operating system. There's no way to get your old apps running directly in Windows 11.

That said, if you're still relying on 16-bit apps then the Docs suggests that rather than investigate workarounds like DosBox (www.dosbox.com) or VirtualBox (www.virtualbox.org), you simply replace your old apps with new, open-source, or freeware alternatives. LibreOffice (www.libreoffice.org) is the obvious replacement for Microsoft Office, while Paint.NET (https://getpaint.net/) is a good substitute for Photoshop, and if Paint.NET is missing features you subsequently need, try GIMP (www.gimp.org) instead.

Search for other alternatives to old programs using the AlternativeTo (https://alternativeto.net/) website.

No life from new build

I am desperate here! I've built a computer from these components and checked at (pcpartpicker.com): GIGABYTE Z690 mobo, Intel Core i5-12600K desktop CPU, 2x 32GB Corsair Vengeance LPX RAM, 2x WD Blue SN570 NVMe drives (1TB and 2TB), Corsair RMX Series (2021), RM1000x, 1000W PSU, and Noctua NH-U9S chromax. Black, 92mm Single-Tower CPU, housed in a SilverStone Technology CS380 8-Bay Compact ATX Tower case, CS380B-X V2.0, Black.

When I plugged it in and turned it on nothing happened! I double-checked the I/O connections. Could it be the connections from the case to the motherboard? I am at a total loss as I have never had a build that did not at least power up at all. Can you help me troubleshoot? **—Lee Gilman**

THE DOCTOR RESPONDS: We ran Lee through all the usual troubleshooting steps, including stripping the PC back to the essential parts to make it boot, but when we asked him to check the connections a second time, he came back with a question that fixed the problem.

After connecting the 24-pin ATX and 8-pin ATX 12V 2x4 power sockets on the motherboard to the Corsair PSU, Lee found that there was no connector for the ATX 12V 2x2 power, so he made use of a 6-pin PCI-E plug from Corsair, leaving two pins hanging.

The ATX 12V 2x2 connector is optional, and only required for extra-heavy loads—you shouldn't connect the 6-pin PCI-E plug to it. Thankfully, given the horror stories online about fried CPUs, Lee disconnected the connector and his new build booted first time.⏻

BUILD A RYZEN PC

Do AMD's new Ryzen chips beat Intel and Nvidia's? *Sam Lewis* finds out

IT'S NO SECRET that Nvidia's lineup of graphic cards dominates the current GPU market. With excellent performance year in and year out, these are the go-to components when you want to ramp up your gaming experience.

However, AMD's Radeon RX cards have been hot on the heels of the GeForce RTX cards from Nvidia for some time now. That has been especially true recently, with the extortionately steep prices of the RTX 4080 and RTX 4090 GPUs making the cheaper Radeon RX 7900XT and 7900XTX offerings look even more appealing. These cards also offer additional features, such as DisplayPort 2.1 support, that the RTX 40 series cards don't currently have.

So in this month's build, we are putting this system up against the RTX 4080 machine we built in our February 2023 issue. This machine hosts AMD's current rival, the Radeon RX 7900XT. Specifically, we have the Asus TUF Gaming 20GB model to put through its paces. Competitively priced, it should make for an interesting head-to-head contest between team Nvidia and team AMD.

Additionally, we have an array of Asus components, including an AIO liquid cooler, a mighty TUF motherboard, and a collaboration between TeamGroup's T-Force sub-brand and Asus's TUF Gaming Alliance for our RAM. For our SSD, we have Solidigm's P44 Pro PCIe 4.0 drive—and all of this will be housed within a brand new NZXT H9 Flow chassis. Although this case is a mid-tower form factor, there's plenty of room inside and it should make for a slick machine with lots of power and even a splash of RGB coming from the AIO fans, RAM, and GPU to add to the visual appeal.

With this system, we will hopefully achieve similar, if not better results than the RTX 4080 machine as we also have a crazy fast AMD CPU to use, the AMD Ryzen 9 7900X. That's rather than the Ryzen 7 7700X we used in that previous build, but still at a similar price point. Not only will this hopefully outperform the latter, but the overall design should also be better— not least because we are big fans of the glass corner look of this NZXT H9 Flow.

So, with that out of the way, it's game on!

INGREDIENTS

PART		STREET PRICE
CPU	AMD Ryzen 9 7900X	$550
GPU	Asus Radeon RX 7900XT TUF Gaming OC 20GB	$1,100
MEMORY	32GB (2x 162GB) Team Group T-Force Delta TUF Gaming Alliance RGB DDR5-5200MHz	$130
MOBO	Asus TUF Gaming X670E-Plus Wi-Fi	$330
SSD	1TB Solidigm P44 Pro PCIe 4.0 NVMe SSD	$130
PSU	NZXT C1000 1000W 80+Gold	$180
CPU COOLER	Asus ROG RYUO III 360 ARGB	$290
CASE	NZXT H9 Flow Mid-tower ATX	$160
OS	Windows 11 Home 64-bit OEM	$32
TOTAL		**$2,902**

WHAT'S IN THE BOX

AMD RYZEN 9 7900X

The other 7000 Series AMD chip we tested in a build, the Ryzen 7 7000, impressed us both with its performance and efficiency, especially at its price point. This time around, though, we are taking things up a notch to the Ryzen 9 lineup.

The Ryzen 9 7900X has a total of 12 Zen 4 cores, 24 threads, and a max boost clock of up to 5.6GHz. That should offer some shockingly fast performance and make using this machine effortless. As if that's not enough for you, with AMD's EXPO technology at hand, overclocking this CPU is certainly an easy option too, for even more out-of-the-box speed.

ASUS RADEON RX 7900XT TUF GAMING OC 20GB

We can finally add one of AMD's latest GPUs into one of our builds. Sure, it's not the top-end 7900XTX card, but this 7900XT from Asus is not to be sniffed at. Built on AMD's RDNA 3 architecture, it can deliver stable 4K gaming with efficiency in mind. This TUF Gaming OC card boasts 20GB of GDDR6 memory, a clock speed of up to 2,535MHz in OC mode, a digital max resolution of up to 7680x4320, three DisplayPort 2.1 ports, and an HDMI 2.1 port. For less than the price of an RTX 4080, it's a strong competitor and doesn't require such a large PSU, although, as you'll soon find out, we have brought one along anyway.
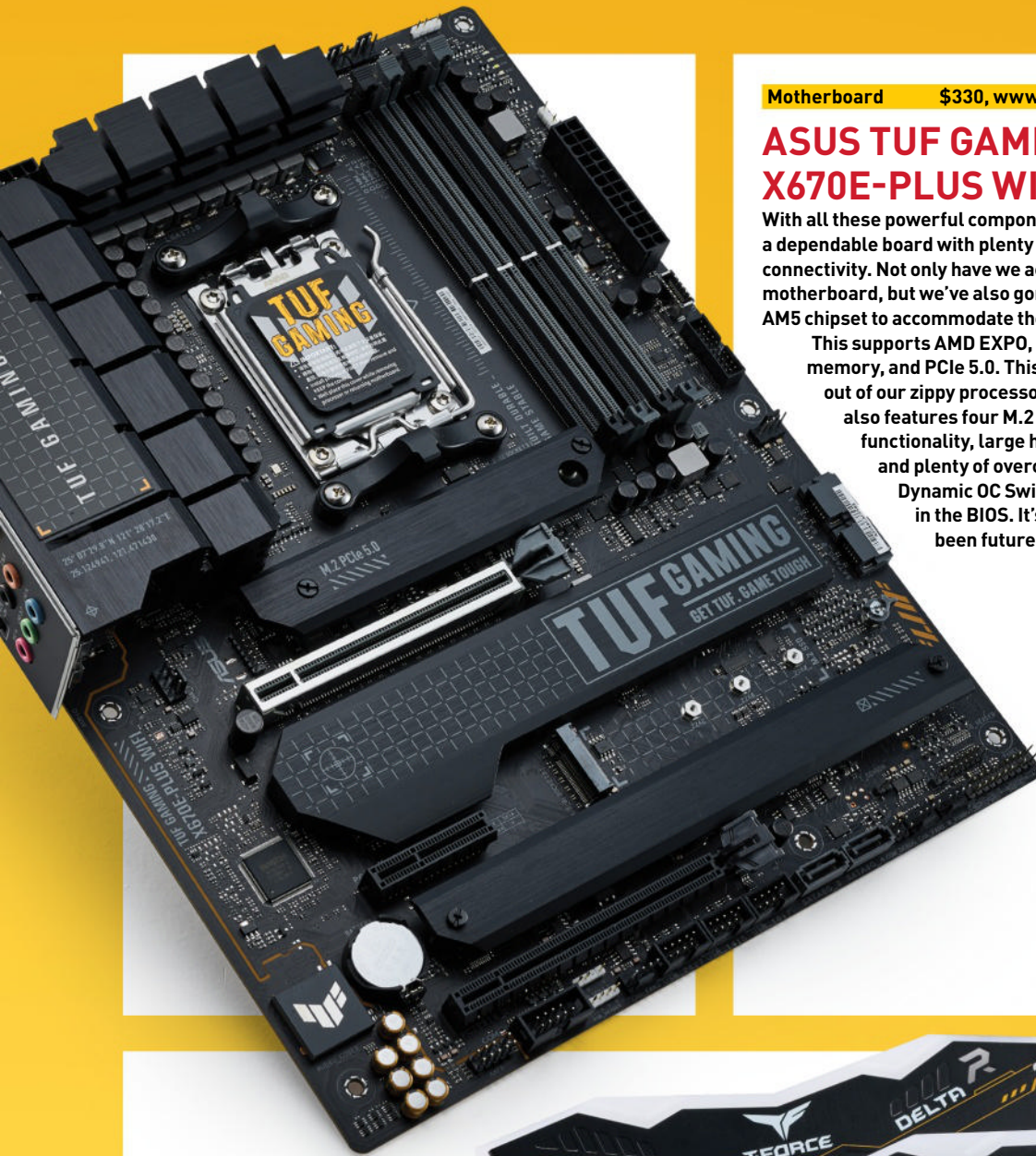
Motherboard $330, www.asus.com

ASUS TUF GAMING X670E-PLUS WI-FI

With all these powerful components, we had to choose a dependable board with plenty of compatibility and connectivity. Not only have we achieved both aims with this motherboard, but we've also gone for the most powerful AM5 chipset to accommodate the Ryzen 9 7900X, the X670E. This supports AMD EXPO, dual-channel DDR5 memory, and PCIe 5.0. This is all to help get the most out of our zippy processor and GPU. The board also features four M.2 Slots, BIOS flashback functionality, large heatsinks for great cooling, and plenty of overclocking support, such as Dynamic OC Switcher and AI overclocking in the BIOS. It's safe to say this mobo has been future-proofed.

RAM $130, www.teamgroupinc.com

32GB (2X 16GB) TEAM GROUP T-FORCE DELTA TUF GAMING ALLIANCE RGB DDR5-4800MHZ

Sticking with the TUF Gaming gear, we have a collaboration between Asus and TeamGroup for our DDR5 memory—specifically, 32GBs of T-Force Delta RGB RAM running at speeds of up to 5,200MHz. This is the first DDR5 RGB OC gaming memory certified by TUF Gaming Alliance and it also features 120° ultra-wide lighting to ensure an even glow from whatever angle. As it's a collaboration with Asus, it works seamlessly with Aura Sync too. It has an impressive cooling system with professional thermal conductive silicone and reinforced PMIC cooling for stable performance.

WHAT'S IN THE BOX

Cooler $290, www.asus.com

ASUS ROG RYUO III 360 ARGB

To keep this PC running smoothly and to keep our temperatures cool, we need a serious cooling system. That's why we've brought in Asus's ROG RYOU III 360 ARGB AIO, which is exactly what we needed for this rig.

What we get, of course, is a 360mm radiator, Asetek 8th-gen pump, Anime Matrix LED Display, and three 120mm ROG ARGB fans. The LED display provides system monitoring, custom animation, Aura sync, or pixel editor, if you are more of the creative type. It's a beast of an AIO, to say the least.

SSD $130, www.solidigm.com

1TB SOLIDIGM P44 PRO PCIE 4.0 NVME

To house the inevitable variety of games and applications, and for speedy file transfers, we've chosen Solidigm's P44 Pro as our drive. Solidigm is a subsidiary of SK hynix and this drive is its second release under this name. Essentially, this drive has the same hardware configuration as the SK hynix Platinum P41 SSD we tried and tested in our RTX 4080 machine, so we knew the performance would be a strong point of this SSD. With read speeds of up to 7,000MB/s and write speeds of up to 6,500MB/s, it will make a great primary drive in this machine.

PSU $180, www.nzxt.com

NZXT C1000
1000W 80+GOLD

Although our Asus Radeon RX 7900XT GPU can run on a 750W power supply, our CPU is hungry for power, most of the time requiring a further 170W. This 1,000W PSU will have plenty of juice for our machine, even if we opt to go down the overclocking route. It's rated at an 80+ Gold efficiency, is fully modular, and has a 135mm fan. That's plenty for our system, if not slightly overkill, but it's better to play it safe. It comes with all the cables we need and, by choosing to go down the AMD route, we don't need to worry about any fiddly PCIe GPU adapters either.

Case $160, www.nzxt.com

NZXT H9 FLOW

Last but by no means least, we have our chassis. We do love an NZXT case, having used many in the past, and we have to say, this is one of the best looking yet. The corner glass design is great for showing off our internals, although an all-white design inside might just have looked cleaner. Having said that, our all-black aesthetic will accentuate the subtle RGB components well. As a Flow variant, airflow is fantastic and the internal space is deeper than the H7 cases NZXT offers too. Around the back, there's a deep channel for cable management too, which makes life a lot easier when building inside!

THE 7900XT MACHINE

7900X MEETS 7900XT – IS IT THE PERFECT MATCH?

LENGTH OF TIME: **2-3 HOURS**

LEVEL OF DIFFICULTY: **EASY**

1 A FLASHY CHASSIS

BEFORE WE GOT TO THIS STAGE, we had a slight issue—every time we picked up this case, we received a static shock. Yep, it's not the nicest of sensations but it was because of the plastic wrapping surrounding the case. To solve this problem, we built on top of an antistatic mat and also wore anti-static wristbands. Each of these items can be picked up for under $15, which is an extra expense, but if it can help avoid frying any internal components, it's a worthwhile investment.

Anyway, after that 'shocking' revelation, we began by stripping down the case to see what we were working with. NZXT cases are typically easy to disassemble. To begin with, take off the top lid, which can be pulled up from the back of the lid, no tools required. Once the top is done, we can take off the front glass panel that has one thumb screw keeping it in place. The same can be said about the back metal panel—it's that simple. With all the necessary panels off, we can now start the building process.

2 A DIFFERENT LOCATION

WE DECIDED TO SWITCH things up here seeing as the PSU location on this case is not in its typical place. The NZXT H9 Flow has a shelf-like system to house the PSU vertically instead of it laying flat at the bottom. This certainly makes adding the cables to the back easier, however, we decided to add the cables in first.

For this build, we needed two PCIe CPU cables, three PCIe cables for our GPU, and a 24-pin motherboard cable. No SATA cables are required here. Then, with these installed, we slotted the PSU on the shelf with the fan facing towards the back panel as it's ventilated. To secure it in place, it's just like any other PSU, tighten it into the case using four case screws and a Phillips screwdriver.

3 THE FIRST 7900

LEAVING THE CASE and the PSU aside for now, we turn our focus to the component that our machine needs to make it tick—the AMD Ryzen 9 7900X. This monstrous processor needs somewhere to proudly sit and, thanks to our Asus TUF Gaming X670E board, now it does. To prepare the throne for the AMD royalty that is the 7900X, first release the retention bar on the CPU socket. Then lift the bracket to reveal the AM5 socket. Align the arrow on the motherboard to the arrow on the CPU and rest it into position whilst holding the sides of the chip. When it's in place, we can now lower the bracket and put the retention bar back in place to secure the processor down.

4 ADDING THE DRIVE

MOVING DOWN, just below the CPU, we have the uppermost M.2 slot, which is typically the best slot to add your primary SSD for the fastest speeds. Whenever you're buying an M.2 SSD without a heatsink (like ours), make sure that your motherboard comes with M.2 heatsinks, as this board does. To start the installation, we need to remove the board's heatsink by loosening the two M.2 screws on either side of it. Store these somewhere safe as they're easily lost! Trust us!

After that, insert the port end of the SSD into the socket and lower it down. This board thankfully had a locking twist screw that secures the SSD into position on the other end of it, so just turn this to hold it down. Once in place, take the heatsink cover, remove the protective film from the bottom of it, and place it on top of the SSD making sure the screw holes line up. Then tighten it using the M.2 screws you've hopefully kept safe.

5 THE MEMORY WITH THE RANDOM ACCESS

TO ADD MORE TUF to our TUF motherboard, we need to add our RAM into the mix. Always check your manual if you're only using two DIMM sticks and have four available DIMM slots to use. The order is important and can cause issues when trying to boot up your system. Typically, the slots you will need to use are two and four, and that was the case here.

Once you're certain of what slots you need, open up the clips by pushing down on them, line the notch of your RAM up with the notch in the slot, and push down. You'll hear a satisfying click as the clips secure it in, letting you know that all is well.
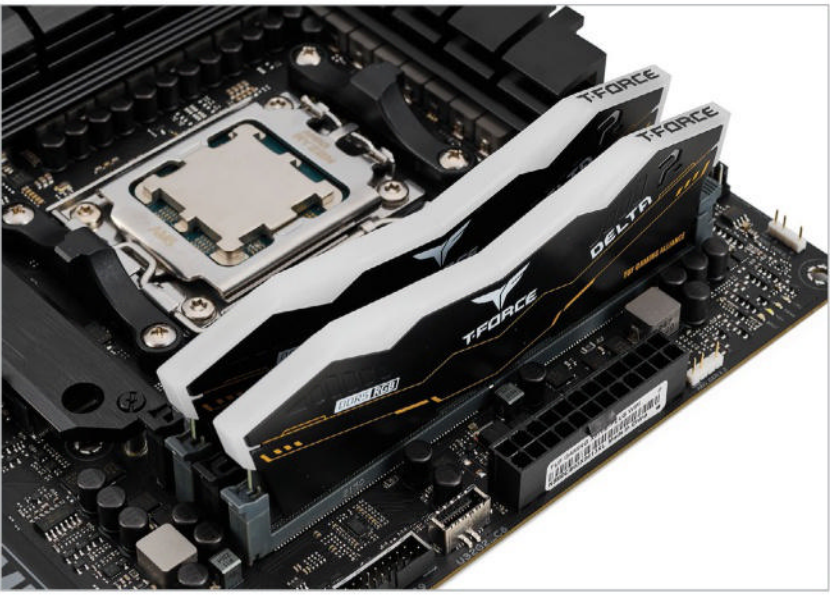
6 CASE MEET BOARD

NOW THAT OUR MOTHERBOARD has the CPU, SSD, and RAM installed onto it, it's time to put it in the case. Rest the NZXT H9 Flow on its back to make things easier and then gently lower the motherboard into the case with the I/O shield going into the slot first. Check that all of the screw holes line up and then begin tightening them in place.

Make sure to tighten diagonally for even tension on the board. Try to use all available screws too, to ensure there are no grounding issues with the case and the motherboard. In this case, specifically, there is plenty of room above and below the motherboard so the installation was a breeze.

7 AIO CPU BRACKET

WITH THE CASE still laying down flat, we can start to prepare for the AIO installation. For this to work, we need to take off the default CPU cooler bracket and install the AM5 one that came with our Asus ROG RYUO III 360 ARGB. These are two small brackets, similar to the stock ones—you simply screw them in place using the stock screws.

On each bracket, there's an arrow pointing toward the CPU, so getting the alignment right is a no-brainer here. All this is in the manual for the cooler and there are also other brackets included for other processors, so make sure to choose the correct one for yours.

8 RADIATOR AND FAN BRACKET

AT THE TOP OF THE CASE is a detachable bracket used to house the radiator and fans for our AIO. This is held on by two screws, so loosen these and slide the bracket toward you to remove it. Once out, we can start attaching both the radiator and the fans. The positioning is important here—we need the fan cables to face toward the back for cable management purposes and for the radiator hoses to come from the right.

The bracket should sit in the middle of the two with the 360mm radiator at the top and the fans at the bottom so we can see the RGB glow inside the case. Most importantly, the fan faces should be facing inwards—faces suck air—and, as this AIO is being used as an exhaust, it needs to suck the air from the inside out. Our case already has three 120mm NZXT fans installed by default as an intake.

9 THE RAD AND FANS GO IN

ONCE THE BRACKET IS READY, we can insert it onto the top of the case again by sliding it in and screwing it down. Now would be a good time to check that the faces of the fans are pointing the right way—admittedly, we installed it wrongly the first time around. Once we'd rectified this, we could start with some cable management.

We ran the four case fans near the headers on the board and used a daisy chain to connect all three AIO fans ready for installation later. We also ran an ARGB cable down the back ready for the lighting, feeding them down the designated cable management channels to keep things tidy. Around the back, there is a hinged panel that you can undo for easy access, which keeps things looking clean.

10 CPU PUMP

THE LAST THING to do with the AIO is to attach the header to the actual CPU, otherwise, you've just got a glorified fan case. As we already have the bracket installed, this is a swift process. Lay the case flat again and make sure the CPU block has the correct attachment for your CPU, in this case, the AM5 one. Always refer back to the manufacturer's manual to confirm. For our build, we made sure the hoses came out from the right side of the pump, so applied a pea-sized amount of thermal paste on the processor and put the pump in its place. Then with the four thumb screws from the AIO box, we tightened it up, working diagonally.

11 THE SECOND 7900

IT'S TIME FOR our 7900XT to be installed, which is one hefty GPU! Before starting, we made sure the case is flat when installing. Remove the two top PCIe shrouds from the case but make sure to keep the screws close by. Open the clip on the top PCIe slot, like you would on the RAM clips, line the GPU up, and push it down gently into place. After it clicks into position, use the screws you put to the side and secure it in tightly.

It became apparent that we had an issue when installing this. Although a neat idea, the mount provided wasn't going to work in this case. With the GPU, Asus provided an extendable leg-like mount that sits at the bottom of the case via a magnet and holds the GPU up from there. It sounds good and does work, having used them before, but this case has a deep floor and it wasn't long enough to reach the graphics card.

Thankfully, once we'd used the screws in the case and secured it into the PCIe slot, there was no visible GPU sag. We don't recommend using a GPU without a mount though, so make sure you have a backup in case you stumble across the same issue. Just to play it safe, we got straight onto Amazon to order a longer mount, which cost us around $10.
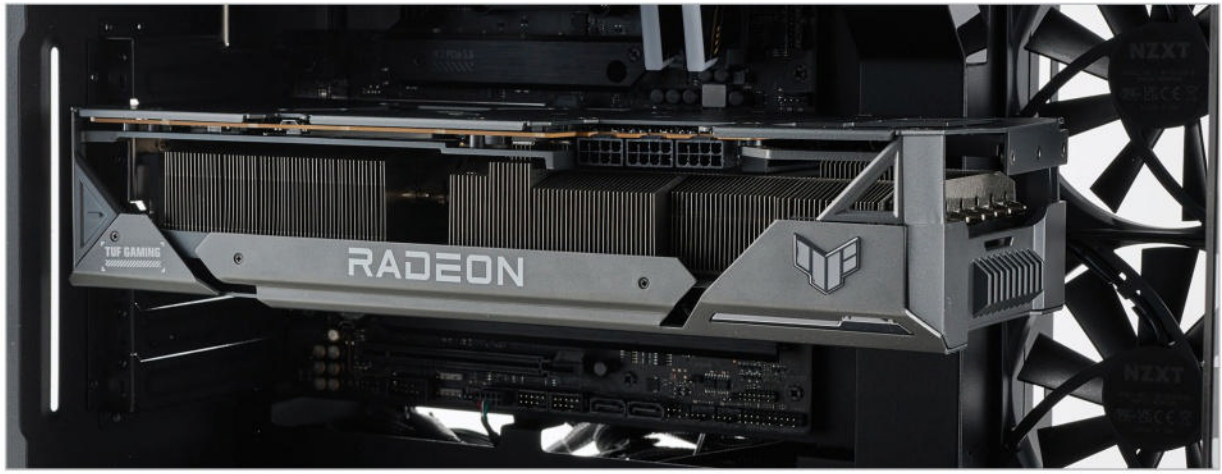
12 AIO AND FAN CABLES

NOW ALL OF OUR COMPONENTS have been connected to the motherboard and installed in the case, we can start connecting the dots. To kick things off, we need to attach the AIO and the case fan cables. Earlier on, we ran these down the back and toward where the headers are, but we didn't connect them, just in case we had to move things around. So at this point, the job was easy. Four 120mm case fans went to individual headers on the board and one header had a daisy chain on it that was connected to the three AIO fans.

We then had to install the two cables that came from the pump header. We connected one cable to the CPU pump header on the top of the motherboard and ran the USB connector around the back and to the bottom of the board for the Anime Matrix LED display.

Last, but by no means least, there was an ARGB cable from the AIO fans that we connected to the bottom of the board to give us the lighting inside the case.

13 CASE CABLES

WITH A TOTAL OF seven fans in this build, RGB lighting, and the AIO pump header cables taken care of, we can start to connect the case cables to the motherboard. This includes the front panel connector (thankfully, these aren't individual pins), USB 3.0, USB 2.0, and the HD audio connector. All of these are straightforward connections.

Again, use the official manufacturer's motherboard manual to double-check where these headers are and plan a route for the cables to follow. As we mentioned earlier, this NZXT H9 Flow has a great cable management system with plenty of velcro straps and channels to keep everything organized around the back.

14 PSU CABLES

REMEMBER RIGHT AT THE START when we installed the PSU cables into the power supply? Well, that's already helped us out enormously here. All we need to do is connect the other ends up to the motherboard, starting with the trickiest, the two PCIe cables that run into the CPU headers on the top left of the board. With the radiator and fans installed it makes this tighter than usual, however, this case has more space to play with so it wasn't actually too bad. With these cables, they clip onto the little notch on the top of the headers so they won't come off easily.

There was a large opening to the right of the motherboard in the case to make it easier to get cables to the board, which certainly helped with the installation of the 24-pin motherboard cable. The last cables to add were the three individual PCIe cables for the GPU. As these were splitter cables, we cable-tied the unused connectors down to the cable to keep it looking tidier. After they were installed, we plugged this into the mains to see if all the lights would come on—spoiler, they did!

15 BIOS UPDATE

NOW WE KNOW THE machine turns on, we need to update the BIOS to make sure we're running on the latest and most secure version in case of any posting errors. Using another PC, head over to the motherboard's official website, in our case, that's www.asus.com.

Find the exact model you're using, go to the support section of the page, then Drivers & Tools, BIOS & Firmware. Here, select the latest version and download it. Then, open the folder to the file and click on the renamer application, which will automatically rename the BIOS file so that the new PC can read it. You will need a clean thumb drive formatted to FAT32, then drag the renamed file onto that.

On the motherboard's I/O panel, insert this thumb drive into the BIOS USB port making sure the PC is shut down. Then press and hold the BIOS FLBK button for three seconds until the LED starts flashing. Leave this until the light is completely off—that means you shouldn't turn off the power, turn on the system or remove the USB drive during the update process.
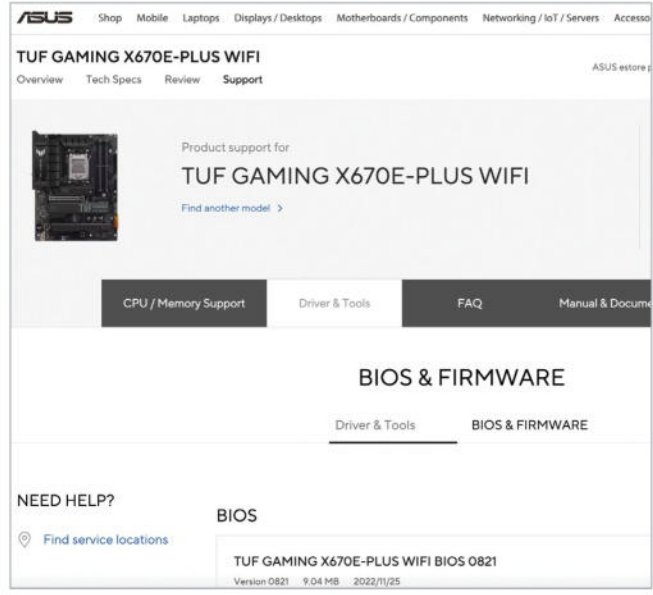
16 WINDOWS 11 INSTALL

AS THE NEW BIOS HAS NOW BEEN INSTALLED, you can remove the drive and plug it into the other PC or laptop you have available. It needs to be reformatted to FAT32 again just to make sure it's completely clean. To do this, right-click on it hit format, and make sure the format option is FAT32. One important thing to mention is that this thumb drive needs to have at least 8GB of capacity to install Windows 11 onto it. With all this checked and ready, head to the 'Download Windows 11' page on the official Microsoft website (www.microsoft.com). Make sure to download the 'Create Windows 11 Installation Media' option and follow the installation instructions.

When asked where to install the OS, select the formatted thumb drive from earlier. Then, after the installation, insert it back into a USB port on the new build. Boot up your system and this will either load the Windows 11 installation up the first time or take you to your BIOS.

If you find yourself in the BIOS, you may have to re-arrange your boot-up priority by making the USB drive the first choice. Once that is done, save and exit and reboot. Then you should be taken to the install page, where you just follow along to set the PC up to your liking.

17 NINITE

THE HUB for all your necessary day-to-day PC applications has to be Ninite. After installing Windows 11, everyone's usually itching to get everything they need to be downloaded onto their fresh PC. This can take up lots of time going from website to website, so why not use one website that can do it all for you? Seems obvious, doesn't it?

Go to ninite.com and on the landing page, select all the apps that you'd like to install. There's a range of categories, including browsers, media, security, utilities, developer tools, online storage, and more. Once you're happy with your selection, click the big 'Get your Ninite' button and follow the onscreen instructions. The program will run and install all the latest versions of the apps selected for you, and even keeps them up to date for you.
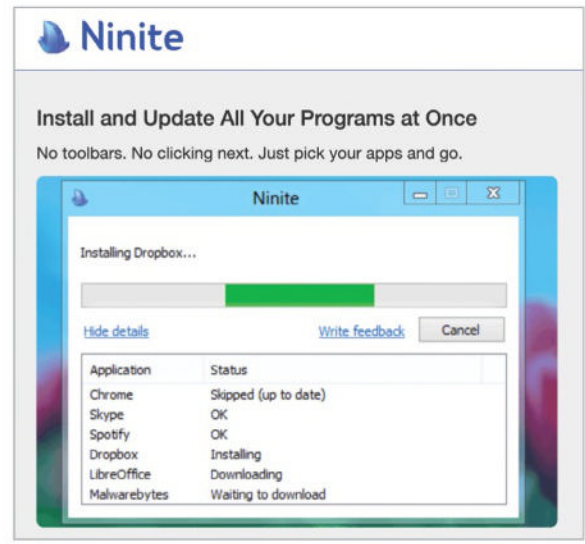
1 As we said before, it isn't advisable to install a GPU without a mount, so next time round, we'd definitely have a spare one ready.

2 Replacing the stock fans here with RGB ones would have given our build a splash of color and made the machine even brighter inside.

3 Although our RAM, with its 32GB capacity, is easily powerful enough, four DIMM sticks might have looked a bit nicer.

4 We're fans of the stealthy all-black design, yet an all-white system with some purple RGB would be a great alternative look.

CONLUSION
7900X + 7900XT =?

AS WE SAID right at the start, in terms of the GPU market, Nvidia has had a stranglehold on the sector for a while, with AMD appearing as the underdog despite releasing many excellent cards at highly competitive prices over the years. With the latest releases of GPUs from both sides, AMD's pricing policy has made the choice of an RTX card even harder to justify over what AMD has to offer.

For example, a quick glance on Newegg (www.newegg.com) shows you can pick up an Asus GeForce RTX 4080 TUF Gaming 16GB for just under $1,200 at the time of writing. Whereas the cheapest boxed Radeon RX 7900XT on Newegg is the XFX Speedster MERC310 Radeon RX 7900 XT 20GB, at $850. For a similar performance, that's quite the price difference. That's also why we are putting this Radeon RX 7900XT machine up against our recent GeForce RTX 4080, both of which are the second-best GPUs from each GPU manufacturer. Both systems are similarly priced, so which one should you opt for?

We will touch on that at the end but first, how did the build go down? With only a GPU mounting issue that was quickly resolved, the construction went pretty smoothly. That is mainly down to how easy it is to work within the case, with plenty of room above, below, behind, and to the sides of our ATX motherboard. Even with the AIO installed at the top of the case, this didn't intrude over the mobo too much. Sometimes adding cables to the top and bottom headers can be a tight squeeze toward the end of a build, but this case made it a breeze.

But despite the benefits of having a deep bottom section of the case, it also brought some negatives, as we soon found out. Our GPU came with an extendable bi-pod-like mount and this just wasn't long enough to stand up in our case to support the GPU, so a longer one was needed. Alternatively, a standard mount or a motherboard mount would

have worked here too. Thankfully, that was our only real issue. Everything booted up the first time, we had no problems with our lighting, all the fans fired up, and cable management was a breeze. Overall, pretty good! So with everything else going well, how well does it run?

BENCHMARK

Not only was the overall build impressive, but so was the performance! It didn't beat our RTX 4080 machine in all areas and, as you can see from our table, it was close in the head-to-head comparisons, but that's our point. With this machine in particular, you get a nicer case and an AIO cooling system, and most importantly, a stronger CPU all for around the same price as the RTX 4080 machine.

From the CPU Cinebench tests, both single-core scores were tight at around the 2,000 mark. However, in the multi-core score, our Ryzen 9 7900X excelled, achieving a score of 29,416—that's a 59 percent improvement on the Ryzen 7

7700X found in the RTX 4080 machine. With a difference like this, it makes it much better for rendering and creative purposes. For our SSD speeds, as predicted, these were similar as our Solidigm P44 Pro 4 has practically the same DNA as the SK Hynix Platinum P41 found in the 4080 machines. So in short, speedy results for both drives.

As for gaming, it was close, but the RTX 4080 topped the results both for *Metro Exodus* and *Total Warhammer III*. However, for *Cyberpunk 2077*, the results were near enough identical, which is great considering the price. Additionally, the 3DMark score for both was only 41 points different, with the Radeon RX 7900XT taking the win here. That said, there isn't a vast difference between these two cards and, seeing as you can purchase a Radeon RX 7900XT card for around the $850 mark, it makes this a higher-value option—one that allows you to spend money elsewhere in your build.

BENCHMARKS

	ZERO-POINT	
Cinebench R23 Single-Core (Index)	1,962	2,078 (6%)
Cinebench R23 Multi-Core (Index)	18,502	29,416 (59%)
CrystalDisk QD32 Sequential Read (MB/s)	7,427	7,336 (-1%)
CrystalDisk QD32 Sequential Write (MB/s)	6,649	6,451 (-3%)
3DMark Fire Strike Extreme (Index)	31,648	31,689 (0%)
Cyberpunk 2077 (fps)	73	75 (3%)
Cyberpunk 2077 RTX (fps)	49	48 (-2%)
Metro Exodus (fps)	91	73 (-20%)
Metro Exodus RTX (fps)	63	41 (-35%)
Total War: Three Kingdoms (fps)	81	69 (-15%)

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

Our zero-point consists of the RTX 4080 build from our February 2023 issue, featuring an AMD Ryzen 7 7700X, Nvidia GeForce RTX 4080 Founders Addition 16GB, ASUS ROG STRIX B650-A Gaming Wi-Fi, 32GB of Corsair Vengeance DDR5-4800, and 1TB SK Hynix Platinum P41 M.2 SSD. All games tested at 4K 'Ultra' graphics presets with DLSS and V-sync turned off and XMP for RAM speed turned on. No manual CPU overclocking.

AMD ADRENALIN SOFTWARE
THE ALL-IN-ONE APPLICATION TO GET YOUR AMD SYSTEM UP AND RUNNING

SO YOUR NEW PC is up and running, your BIOS is updated, Windows 11 is installed and updated, and you've been over to Ninite (www.ninite.com) to download some of your favorite applications. But before you try them out, you need to update and check your system is running as it should. If you're using an all-AMD PC like ours, then AMD's Adrenalin software should be your first destination. This application provides the latest driver updates, performance monitoring, and Hotkeys.

On the landing page, one of the most important things to check before starting to use your system for gaming is whether your CPU or GPU drivers are up to date. On the right-hand side, there is Driver & Software window, hit the check for updates button here and install if necessary.
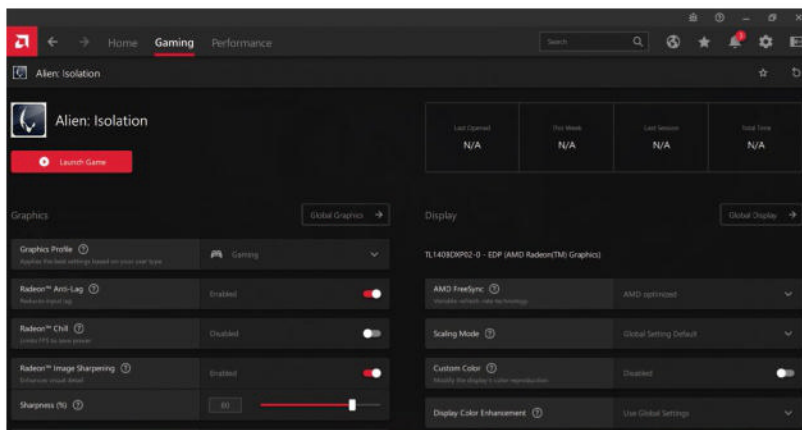
Other than that, there are plenty of settings and tools to play around with, so let's take a look at the best parts of this application in further detail.

1. GAME LAUNCHER

THERE ARE PLENTY of applications that will handle launching your games, but it's great to see this feature appearing here in AMD's Adrenaline Edition. Within the software, head to the gaming section along the top menu and you should see all of your installed applications in one place. When you select a game that you want to launch, it opens a new page where you can tweak a few settings.

As you can see, there's a range of graphics and display options to play with. You can choose a graphical profile that includes a setup for gaming, eSports, power saving, and standard. There are also toggles for Radeon Anti-Lag, Radeon Chill, Radeon Image Sharpening, AMD FreeSync, and much more.

Along the top, there's a set of stats where you can keep tabs on how long you've been playing a particular game, although bear in mind that can also be a little alarming.

© AMD
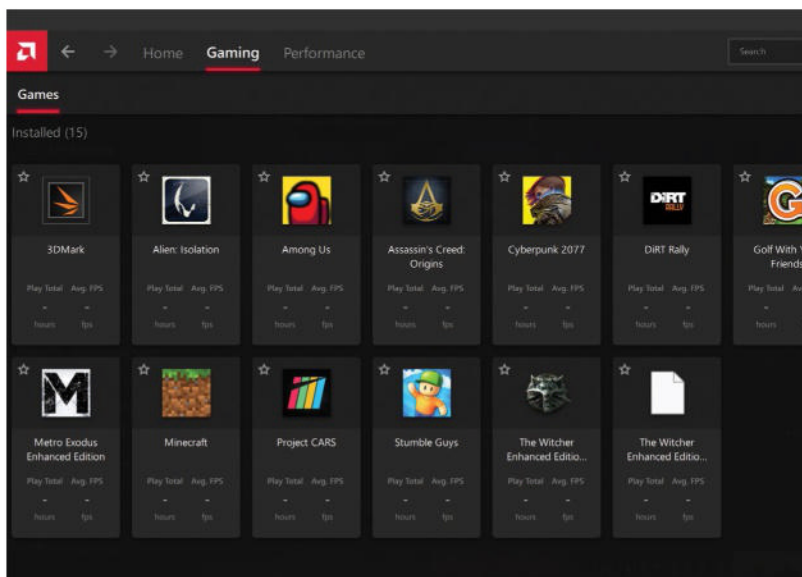
2. PERFORMANCE

NOT ONLY CAN YOU launch your games from Adrenaline, but you can also monitor your system by heading to the Performance section in the top tab. The landing page here will show you the current FPS of a game, GPU/CPU/VRAM/RAM utilization percentage, and on the right-hand side, you can start tracking your performance.

With this feature, you can specifically monitor your hardware performance during a set time or just test out one specific game, for example. It's a good way to benchmark your machine when overclocking. You can check which parameters you want to log using the toggle switches. This is useful if you want to focus on a specific element of your PC's performance.

Moving along from the Metric tab in the Performance part of the application is the Tuning page. This is where you can automatically tune your CPU and GPU. You'll be able to monitor clock speeds, overclock offsets, voltage, power consumption, and your current temperature here.

Last but not least, there's an Advisors page where you can choose the profile that suits you and the software will sort everything out. Here, there are options for gaming, eSports, power saving, and standard profiles, just as we have the option to change settings for individual games, only this applies to everything. Have a tinker around!
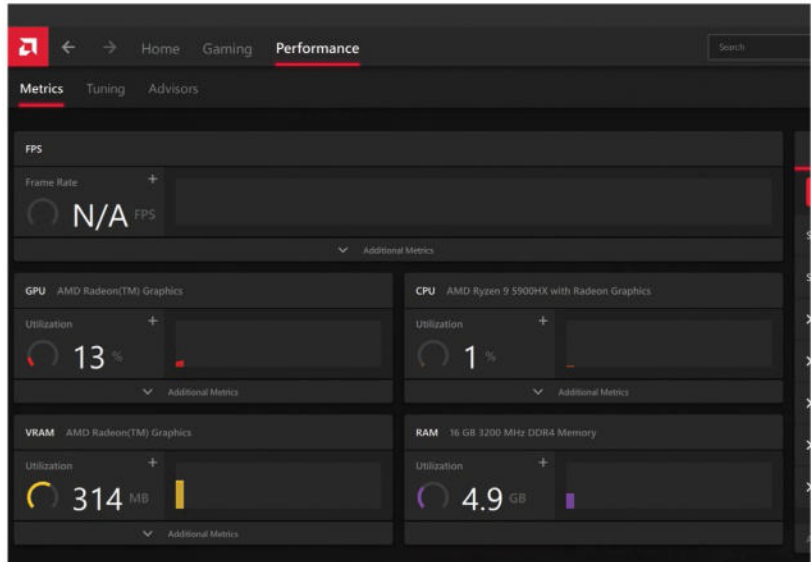
3. SETTINGS

IF YOU WANT MORE of everything, what better place to start than the settings page? This is the perfect place to delve a little further into what this application can do. From the system landing page within the settings, you can see the current version of your app and any available updates. You can also see what hardware you're running on the right-hand side of the page. Below both of these, there are toggles for automatic update checks and automatic update downloads, plus options to reset your stats or carry out a factory reset on the app.

Along the next tab in the settings is a graphics page. Here, you can choose a graphic profile just as you can in the performance advisors section and you can also toggle some Radeon features here. On the display page, there are settings for GPU scaling, super-resolution, AMD FreeSync, custom color profiles, and more.
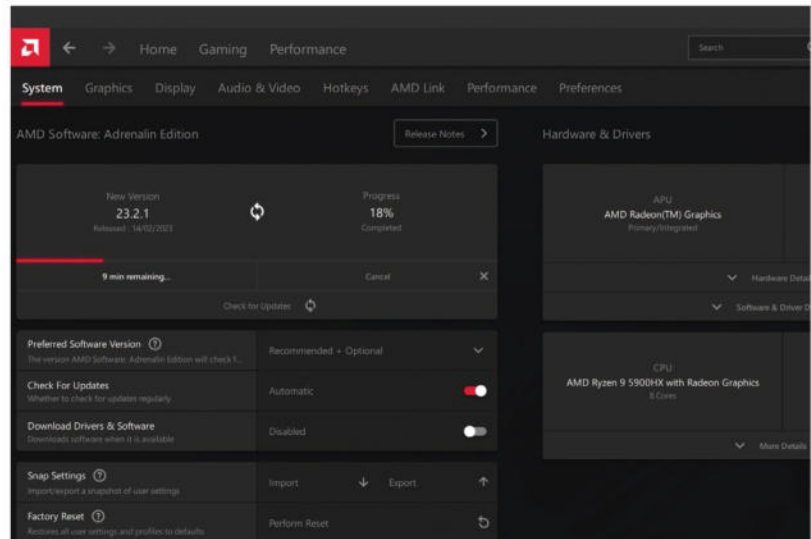
Further along, you can change your video profile from default to either cinema classic, enhanced, home video, outdoor, sports, vivid, or custom. Finally, there is a Hotkeys section for enabling settings via key combinations. You can turn on Radeon Chill, Radeon Anti-Lag, and Radeon Boost here just from some Hotkey options, which is pretty handy during a game! ⏻

Nick Peers finds ways to eke even more use out of your old laptops, phones, and tablets

BREATHE NEW LIFE

INTO OLD KIT

That old laptop gathering dust in the corner has plenty of life left in it yet. Windows may have moved on, but you'll be surprised just how much you can still do with it. The same is true of your old smartphone and tablet too. Official support may be a thing of the past, but that doesn't mean it can't be kept updated and secure while it continues to serve a new purpose in your home.

The built-in obsolescence in tech is staggeringly wasteful. Not everyone needs—never mind wants—to upgrade every year or so, and unless you're ruthlessly organized, it's easy to accumulate a pile of supposedly redundant tech that, with just a bit of thought, can continue to serve your needs for many a year yet.

In this feature, we tasked ourselves with finding new uses for the laptops and mobile devices currently sitting unloved in the corner. You'll be pleasantly surprised at the results: a 12-year-old laptop has a new life as a sleek and responsive Chromebook, a 2013-vintage Nexus tablet is now running Linux apps, while an eight-year-old smartphone is happily running a fully patched and updated version of Android 11. Read on for some inspiration as to how you can breathe new life into your old kit.

LET'S START WITH that neglected laptop. First of all, examine what upgrade options are available: you can do a lot more with 4GB than 2GB (and even more with 8GB or 16GB), so visit www.crucial.com and use its memory finder tool to see how much an upgrade will cost you. While you're at it, pop open your laptop's drive cover and consider upgrading it to an SSD if you haven't already done so.

Both upgrades will ensure your laptop is not just more responsive, but better suited to a wider range of alternative uses. Depending on your laptop's age and spec, you might be able to press it into service as a dedicated games server. Note: games servers are best employed for smaller groups of people, ideally on the same local network, but if you have a super-fast broadband connection, then you should be able to host smaller groups of people remotely too.

You'll naturally have more success with older, less demanding games—think *Minecraft* or *FiveM*—but ultimately, you'll need to consult a game's documentation to determine if your laptop has enough horsepower in terms of CPU, RAM, and networking, but graphics is not an issue for dedicated servers. It's also worth looking into the game's operating system requirements, if you can run it under Linux (see https://store.steampowered.com/linux for a list of Linux-compatible titles on Steam, for example), then you may be able to eke out better performance by ditching Windows in favor of Ubuntu.

Extra RAM and an SSD drive can do wonders for an aging laptop.

Run your own server

If gaming is too much, or you're looking for more uses for your old laptop, another option might be to turn it into a low-powered 24-7 server, running all manner of personalized cloud services. If the idea of running everything from your own password manager (see page 62) to an audiobook server (see page 66 of the Holiday 2022 issue) appeals, then we recommend building it on Ubuntu Server, cockpit, and docker, as outlined in our NAS build from the September 2022 issue. One key consideration is storage; if you have gigabytes (or even terabytes) of data you wish to serve from your laptop, you'll need to attach one or more suitable external USB drives to house it all.

The beauty of your laptop server is that once set up with the cockpit web-based interface for remote access, you can tuck it away out of sight. There are two considerations, here: first, cockpit uses a different networking stack to Ubuntu Server, so you'll need to tweak some settings to gain full functionality from it. The following steps should suffice:

```
sudo nano /etc/NetworkManager/conf.d/10-globally-managed-devices.conf
```

Populate the empty file with the following two lines:

```
[keyfile]
unmanaged-devices=none
```

Press Ctrl + X, followed by Y, and return to save the file and quit nano. Now enter the following commands:

```
sudo nmcli con add type dummy con-name fake ifname fake0 ip4 1.2.3.4/24 gw4 1.2.3.1
sudo reboot
```

When you reboot, you should be able to log in and use all of cockpit's features, including the critical software updates feature. The next consideration is what happens when you close your laptop's lid. By default, Ubuntu is configured to put your laptop to sleep, so you'll need to change this behavior. This is done by editing a configuration file:

```
sudo nano /etc/systemd/logind.conf
```

You'll see a configuration file appear. Scroll down to the #HandleLidSwitch=suspend entry and change it to 'HandleLidSwitch=lock', then do the same for the following line so it reads 'HandleLidSwitchExternalPower=lock' (removing the # from each line enables the feature). Not only should this prevent your laptop from going to sleep, but it should also switch off the display
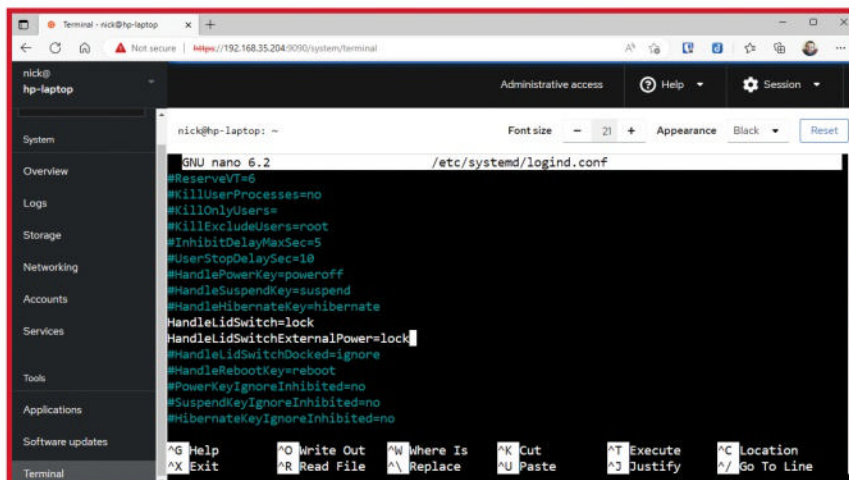
Prevent your laptop lid from putting your new server to sleep

after a short period. Once you've saved and exited nano, enter the following command to enable the feature:

```
sudo systemctl restart systemd-logind.service
```

Test the feature is working by shutting the lid of your laptop—if it goes into suspend, you'll lose access via cockpit, but if you're able to continue interacting through cockpit, then the tweak has worked.

One final tweak: you'll see a message about a redundant app called cloud-init appear at the logon screen. To remove this, simply type:

```
'sudo apt remove cloud-init'
```

then hit Enter to remove the package (and the prompt).

Switch OS

If you don't need a server, why not use your laptop to explore a desktop version of Linux, complete with user-friendly front end? All Linux distros are less resource-heavy than Windows or macOS, so even switching to plain vanilla Ubuntu (www.ubuntu.com/#download) should see your laptop regain some of its lost responsiveness. We recommend the LTS version, as it's only updated every two years and each version is supported for five.

If your laptop is short on memory or over six years old, you'll find distros that are even lighter on system resources. Linux Mint (www.linuxmint.com) has long been recommended for Linux switchers—start with the MATE edition, and if that's too resource-heavy, try Xfce instead. If you're a MacBook user, you might like to explore elementaryOS (www.elementary.io/) as a possible option. If you plan to install Linux alongside macOS, check out www.rodsbooks.com/refind/ for an essential boot manager.

Another option for those looking to transform their laptop into a lightweight device is to turn it into a pseudo-Chromebook. ChromeOS Flex is Google's official implementation of the Chromebook OS for Intel-based PCs and Macs, and it will effectively turn your laptop into a cloud-first device, the equivalent of a 'Thin PC' whereby it uses remote servers and computers to do all the heavy lifting.

You'll need the Chrome browser installed on your Windows PC to install the Chromebook Recovery Utility extension. However, this doesn't work in other Chromium-based browsers, such as Edge. Then go to chrome.google.com/webstore/ and search for 'Chromebook Recovery Utility' to find and install the extension.

Once in place, open the plugin and have an 8GB flash drive ready to go. When prompted to identify your Chromebook, click 'Select a model from a list', then choose 'Google Chrome OS Flex' from the 'Select a manufacturer' dropdown and 'Chrome OS Flex' from the 'Select a product' dropdown before clicking Continue and following the prompts to create the USB flash installer.

Once done, remove the flash drive and boot from it on your laptop. You can road-test it in a 'live' environment, but if you want to run the full gamut of features, you'll need to install it on your hard drive. This is a destructive process—you can't install chromeOS Flex alongside another operating system. After about 20 minutes, your laptop will power down, at which point, pull out the USB drive and press the power button to boot into it. The box opposite reveals what to expect when using your new Chromebook.

Extend the life of your old Android device

Have you got an old tablet or phone knocking around that hasn't been updated in years or has just fallen foul of the manufacturer's short support cycle? There's plenty you can do to eke more life from it, either as your primary phone or by giving it a whole new purpose.

When it comes to Android devices, you may be able to extend their lives by simply installing a new operating system. There

USING CHROME OS FLEX

After running through a brief setup wizard, you'll find yourself at the main Chrome OS desktop, not unlike that of Windows or macOS. Sadly, despite appearances, this isn't a full-blown copy of the OS found on Chromebooks—there's no Android app support for starters, but you may get lucky and find Linux support is forthcoming: navigate to Settings > Advanced > Developers and, hopefully, the magic switch won't be grayed out (as it was on our aging HP Pavilion g6-1d67cl laptop). If it is, check to see if your laptop's processor supports virtualization and if so, you may need to enable it in the BIOS to gain access to Linux.

If you're able to enable Linux support, you'll be able to run commands from the Terminal, and even install desktop apps like Gramps using 'sudo apt install'. But even if not, there's still plenty you can do from the Chrome browser as well as various preinstalled apps (other apps are available via the Chrome web store).

One use for your new Chromebook (or indeed your Linux-powered laptop) might be to control your main PC remotely, say from another room or even another city. The simplest option here is to utilize Chrome's own built-in option in the form of Chrome Remote Desktop (https://remotedesktop.google.com/). Once you've installed the Chrome extension and the desktop app on your main PC return to the Remote Desktop homepage, select 'Remote Access' in the left-hand pane, and click 'Turn on'. Set a suitable six-digit PIN and then test the connection by browsing to the same address on your laptop, where you should be able to access your home PC from the same 'Remote Access' section.
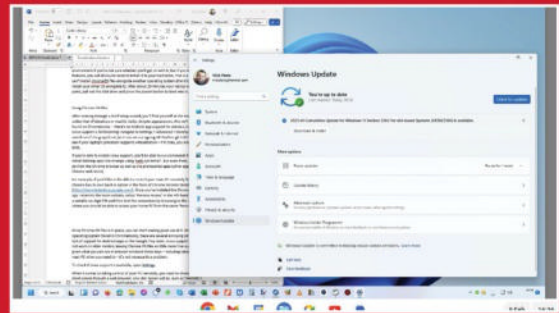
Turn your laptop into a Thin PC client with Chrome OS Flex.

are many alternatives out there, but we're focusing on two in this feature. The first is LineageOS (https://lineageos.org/), which is built from the Android kernel and provides older devices with access to newer versions of Android, ensuring they're able to receive security updates and bug fixes for longer. For example, a 2013 Google Nexus 7 tablet that hasn't been supported since Android 6.1 in 2016 can now run LineageOS 18.1—based on Android 11—bringing it bang up to date.

If you're fed up with Android and want to try something new, we'll also run through the process of installing Ubuntu Touch (https://ubuntu-touch.io/) on your phone or tablet instead. Ubuntu Touch comes with its own somewhat limited app store, but because it's built on the Linux kernel, can be used to run a wider variety of Linux desktop apps too.

UBUNTU TOUCH TIPS AND TRICKS

Ubuntu Touch ships with a handful of pre-installed apps, including the Morph Browser, Camera (and Gallery image viewer), and Media Player. Although its built-in OpenStore app store is rather disappointing, what Ubuntu Touch offers that you won't get elsewhere is a fully functioning Linux OS on your tablet or phone. You'll have access to a fully functioning Terminal and can even install desktop apps, which opens up all kinds of possibilities.

Desktop apps are installed in self-contained 'Libertine' containers—navigate to Settings > System > Libertine to get started. Each container is given its own name and optional password for security, and you can install any app that's in the Lubuntu Software Center. For further details, search through the online documentation at (docs.ubports.com/en/latest/userguide/dailyuse/libertine.html).

To really make the most of Ubuntu Touch, particularly if you plan to spend a lot of time with Libertine apps and the Terminal, we recommend pairing a Bluetooth keyboard and/or mouse with it, or alternatively, make use of your PC. If you connect your device via USB, you can run Terminal commands directly from the Windows Terminal simply by typing 'adb shell' and hitting Enter to get started. Or follow the guide online to setting up ssh access, allowing you to 'dial in' wirelessly to your Ubuntu Touch device from the Terminal.

A handful of devices, including the Nexus 5 and OnePlus One phones, can even run Android apps through Ubuntu Touch using the Anbox container (https://docs.ubports.com/en/latest/userguide/dailyuse/anbox.html), while others have reported success (most notably with the Pixel 3a) with the newer Waydroid (https://waydro.id/) container. That said, if your main intention is to keep running Android apps on your phone, you're probably better off trying LineageOS instead.

Install Lineage OS from the comfort of Windows Terminal.

navigate to Settings > System > About this phone/tablet, then tap the Build number until you unlock the developer tools. Now go to System > Advanced, where you'll see a new 'Developer options' entry has appeared. Tap this and flick the 'USB debugging' switch on. Windows should then proceed to set up the device anew and, once it's ready, test the connection by opening Windows Terminal and issuing the following command:

```
adb devices
```

After a short pause, a new daemon will be started and you should switch focus back to your phone or tablet and you'll be prompted to allow USB debugging. Tick 'Always allow...' and tap OK. Run 'adb devices' again and it should now say 'device' instead of 'unauthorized'.

Before going further, make sure any critical data—photos, videos, and the like—on your phone or tablet has been backed up because the next steps will wipe your device completely. From the Windows Terminal, issue the following command:

```
adb reboot bootloader
```

Your phone will restart into fast boot mode, waiting for your next instruction. Before proceeding further, you'll need to install additional drivers on your PC. Open Settings > Windows Update and click 'Check for updates'. When the update completes, click Advanced Options followed by Optional updates where you should see that two driver updates have been found. Tick both (Android Bootloader Interface and USB) and click 'Download & install'. Once the drivers are in place, type:

```
fastboot devices
```

Your device should be listed, and you're now ready to switch to a new operating system.

Install LineageOS

To convert your phone to a newer version of Android using LineageOS, navigate to https://download.lineageos.org/, click the (≡) icon in the top left corner, and select your device manufacturer followed by the model to access the required files: a recovery .img file and a much larger .zip file containing the installation files. Download both to your personal Downloads folder, then issue the following commands in the Windows Terminal (substitute recovery_filename with the name of the .img file:

```
cd Downloads
```
```
fastboot flash recovery recovery_filename.img
```

Now follow the instructions on the LineageOS Wiki for your specific device (click 'Installation instructions' on the builds page if necessary) to reboot your phone in recovery mode.

From your phone, tap Factory Reset followed by 'Format data/factory reset' and 'Format data'. Return to the main screen and then tap 'Apply update' followed by 'Apply from ADB'. Switch back to the Terminal and start typing'. One handy hint here, after typing 'lineage', press Tab, and the Terminal should autocomplete the rest of the filename for you:

```
adb sideload lineage_filename.zip
```

Unfortunately, you can't just take any old phone or tablet and expect it to magically work—devices must be explicitly supported by either OS. This means that you will need to check the relevant website to find out whether your device is supported—as you'd expect, the more mainstream your model, the more likely it is to be supported.

At the time of writing, Ubuntu Touch (https://devices.ubuntu-touch.io/) supports a total of 96 devices from manufacturers including Samsung, Google, OnePlus, and Motorola, while LineageOS (https://wiki.lineageos.org/devices/) currently supports over 170. Each website offers specific instructions for the supported models, so take the time to read those before continuing. You should also take this opportunity to back up your mobile as you're about to wipe it completely clean.

Prepare your Android device

Whichever option you choose, you'll first need to install some prerequisites on your PC. These are the adb and fastboot tools, which allow you to control your mobile from the Windows Terminal. The quickest way to get these is via the 15 seconds ADB Installer (forum.xda-developers.com/showthread.php?t=2588979).

Once installed, plug in your Android phone via a USB cable and

You should see the installation progress, first through the Terminal, and then on your device. Once installed, you'll be told the script has succeeded and find yourself back at the recovery screen. If you're happy to move on without relying on any Google apps or services (including the Play Store), tap back followed by 'Reboot system now'.

If you want to incorporate Google into your new phone for a more familiar Android exprience, you'll need to sideload another file before rebooting your phone. Obtain this from wiki.lineageos.org/gapps—make sure you choose the correct build for your version of LineageOS and remember to choose arm64 for 64-bit phones, and arm for 32-bit models.

Once downloaded, sideload the file as before:

```
adb sideload MindTheGapps-filename.
zip
```

This time around, you may receive a 'Signature verification failed' message—tap Continue if this is the case. Once complete, tap back and choose 'Reboot system now'.

Using your new operating system

LineageOS makes no effort to hide its Android origins, which means you should instantly feel at home. Once loaded for the first time, tap Start and follow the instructions to run through the setup wizard.

If you've installed Google's services, the setup wizard will offer you the opportunity to sign into your Google account and restore a backup from your previous installation before moving on to the LineageOS setup wizard, which is much shorter.

If you've decided to make a clean break from Google, the first thing you'll notice is the complete absence of any app store, and the clean, spartan interface. To substitute Google Play with the F-Droid app store, go to https://f-droid.org in your Android browser and tap 'Download F-Droid'. Tap Allow followed by Download, then open the .apk file and allow your mobile to install apps through Browser to complete the process.

With F-Droid installed, you'll have access to most of the apps you could possibly need, allowing you to continue using your phone with a fully updated OS for months, if not years, to come.
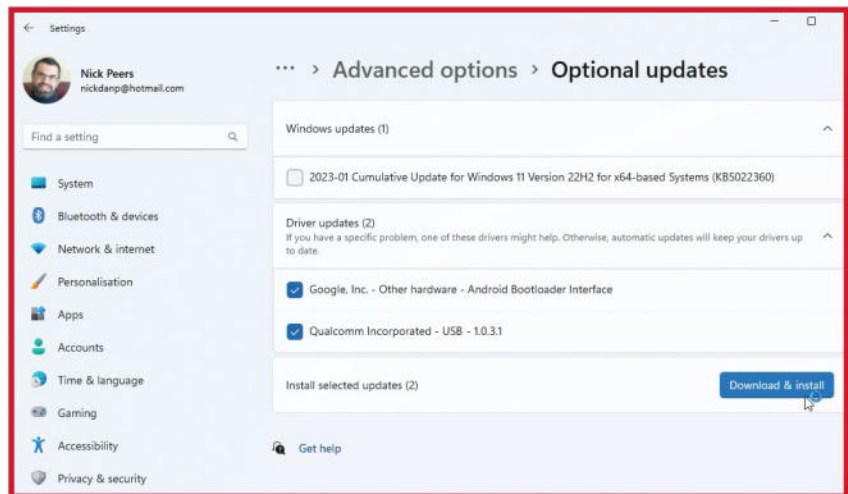
Gaining control of your Android in Windows requires more drivers.

Install Ubuntu Touch

Ubuntu Touch is a slightly easier prospect to install than LineageOS. Simply navigate to your device's page (devices.ubuntu-touch.io/device/flo for Wi-Fi Nexus 7 users, for example) and download the UBports Installer. Double-click this and follow the prompts. If you get a warning about the device being locked, which should be confirmed on the device's own bootloader screen, issue the following command in the Windows Terminal:

```
fastboot oem unlock
```

Read the warning and select Yes using the controls prompted. You should return to the start screen on your device and see the lock state is now unlocked. Meanwhile, the UBports Installer will ask you to configure your new installation by choosing a release channel (stable is best), plus offer a series of tick boxes. Follow the recommendations, including formatting the system partitions, and then it will download the required files.

Shortly after these are downloaded, and after you've confirmed the device has rebooted, you'll see the screen showing the Ubuntu recovery screen for the first time. Ignore any warnings and wait while the UBports Installer downloads and verifies installer files to your PC. After these have been 'pushed' to your device, it will automatically reboot, and Ubuntu Touch should now install on your device.

Exploring Ubuntu Touch

After installation completes, a further reboot will take place and Ubuntu Touch should load and take you through a quick setup wizard, then provide a short tour of its key navigation tools. Anyone who has experience with Ubuntu, particularly the 16.04 variant that Ubuntu Touch is based on, should have little trouble acclimatizing to the user interface.

The key thing to come to terms with is the lack of a 'home' screen or button. Instead, you pull in the app shortcuts from the left, or cycle between all open apps by quickly swiping from right to left. Swiping more slowly brings the app launcher up, from where you can navigate directly from one app to another or close individual apps by swiping their tiled entry up.
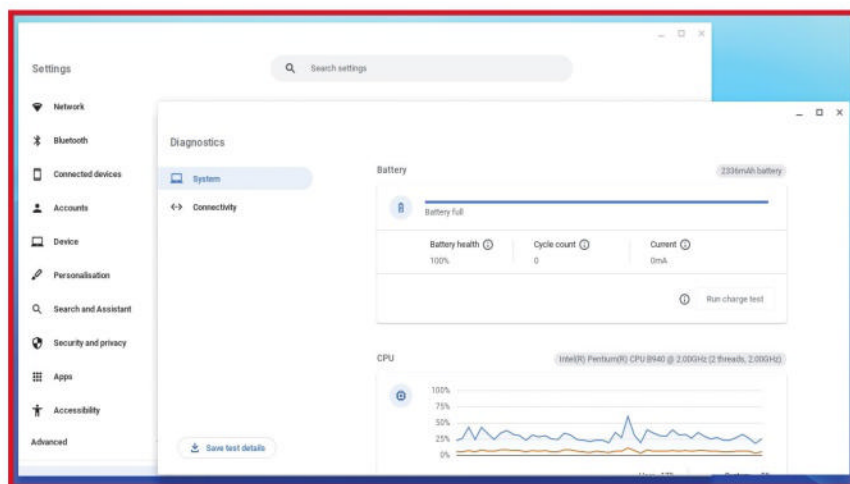
Chrome OS Flex runs beautifully on older chipsets.
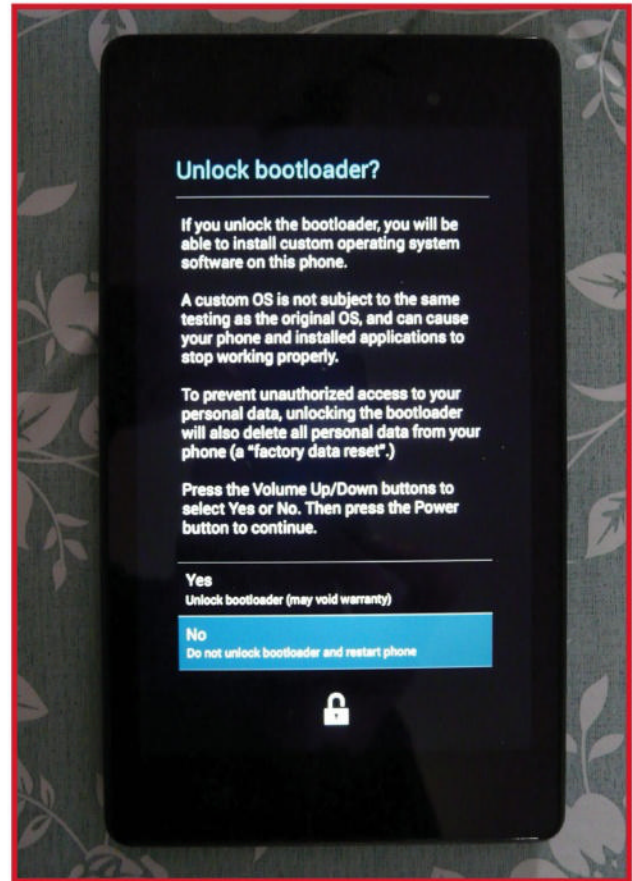
You'll need to unlock your bootloader to install Ubuntu Touch.

If neither Ubuntu Touch nor LineageOS take your fancy, or your device isn't supported, don't give up. There are plenty of other alternatives to try—/e/OS (e.foundation/get-started/) is another Android variant that works with 211 models. This offers open-source alternatives to all Google apps as well as anonymous access to Google Play and F-Droid app stores as standard. Another project worth keeping an eye on is postmarketOS (postmarketos.org), another Linux-based project with a strong focus on keeping old phones functioning and out of landfill.

Convert your device to single usage

Some devices may appear to be beyond saving—even with a new OS, they may still function too sluggishly to remain in service as your primary phone or tablet. But before binning or passing them on, consider limiting them to one or two specific usage scenarios. This especially applies to old iPads and iPhones, which can't be converted to a different OS—see ipadlinux.org for the latest developments in getting a Linux shell onto iOS.

The only logical alternative for iOS users is jailbreaking, which unlocks various aspects of the latest available iOS version. This can give you access to apps no longer supported or available from Apple, but the only real reason to attempt this would be if you couldn't find a working app to perform the new role you've envisaged for it.

One thing we do recommend if you're planning to reuse an old phone or tablet is to wipe your device and start again from scratch—you'll clear out a lot of clutter and enjoy a much better performance by doing so. If your old iPad or iPhone keeps claiming that 'verification failed' during setup after entering a code generated by another iOS device, choose to receive the code

Ubuntu Touch comes with its own relatively pleasant installer.

by a different method (such as an SMS message). Once done, visit discussions.apple.com/docs/DOC-10344 for some useful tips to improve performance in iOS 9 through 12, should your older iOS device have slowed down after its last major iOS update.

You're now ready to consider what to do with your older device. Let's start with something basic, that requires no third-party app: converting your old tablet into a digital photo frame or bedside alarm clock. All you need is your mobile's built-in Photos or Gallery app and its slideshow feature for the former, or the Clock app for the latter. In either case, consider investing in a stand—you'll find loads of examples on the likes of eBay and Amazon, with prices starting from as little as $12. Search for 'iPad stand' or 'Android phone stand' to see what's available—look for one that allows you to tuck your device's power cable out of the way, as you'll need it plugged in permanently to ensure the screen doesn't dim or your battery run down.

Other dedicated single uses could be as an eBook reader (a more practical choice if your screen supports night-time reading, such as with the iPad 5 or later), a streaming media player, or a controller for your remote server. Another idea might be to use your old phone exclusively as a music player in the car, connected via a 3.5mm cable or wirelessly via Bluetooth. Rather than stream music, look to store as much of it on the phone as possible (easier with an Android phone thanks to more common expandable storage) so you'll always have your music, even in dead spots.

More advanced ideas

How about converting your tablet into a secondary display? A free tool called Deskreen lets you use any device with web access as a secondary display for your PC or Mac. Download the client from deskreen.com/lang-en and then install and launch the app. Click the blue button to skip past the splash screen, then either scan
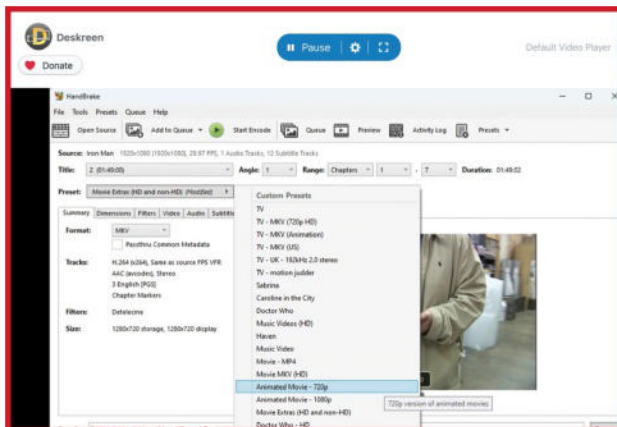
Use your old phone or tablet as a secondary screen with Deskreen.

the QR code into your tablet or manually type the following web address, substituting 192.168.x.y with your desktop's IP address, and 000000 with the number displayed on the screen:

`http://192.168.x.y:3131/000000`

You'll then be prompted to allow the connection before being given the opportunity to either mirror the entire screen or display a specific application window—the latter is perfect for monitoring a program while it's hidden behind other windows. If you have a Virtual Display Adapter to plug into a spare HDMI port (or explore workarounds at github.com/pavlobu/deskreen/discussions/86), you can even use your tablet as a second screen for extending your desktop on to.

Another use for an old phone or tablet is as a camera. You could go for something whimsical like using it to create timelapse photography. Try Triggertrap Mobile ($3 for iOS 10.0 or later), which is a fun app that adds a series of triggers based on your iPad's sensors, from sounds and vibrations to timers and face recognition.

Alternatively, press it into action as a security camera. You'll find plenty of apps offering to reuse your old mobile's cameras in this way. One that's compatible with older devices is Alfred Home Security Camera (https://alfred.camera/), which works with both iOS (10.0 or later) and Android (5.0 and up). ⏻

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Erase ALL Your PRIVATE DATA

Remove personal data from your PC to prevent others from seeing it. *Robert Irvine* explains how to remove all trace of your activities using two free tools

WHAT YOU CAN DO

- Wipe details of recently opened files and programs
- Overwrite deleted data to make it impossible for others to recover
- Remove leftover traces from the Windows registry
- Delete unwanted tracking cookies while retaining essential ones
- Erase your browsing history from all your browsers
- Delete stored passwords and info you type into online forms
- Shred files and folders containing sensitive data

ANYONE WHO WANTS to know what you've been doing on your computer—both online and offline—can find out in just a matter of seconds. Your PC stores details of all your Windows and web activities, including the files you open, the sites you visit, and the software you use, and makes this information easy for you to access. However, this also makes it easy for others to access, which significantly compromises your privacy, even if you have nothing to hide.

Manually deleting personal data from all the programs you use can be time-consuming and confusing, and traces of your activities are inevitably left behind, allowing savvy snoopers to see exactly what you've been up to. To completely erase all these elements so they can't be recovered, you need a dedicated privacy cleaner. Thankfully there are two excellent free tools available.

Privacy Eraser (www.cybertronsoft.com/) and PrivaZer (privazer.com/en/index.php) will both purge your PC of all private data and leftover traces, including temporary files, tracking cookies, and usage logs.

In this feature, we reveal the options you can use in both programs to perform the most thorough clean-up possible and hide all details of your activities from prying eyes. We'll explain which boxes you need to tick, where to find them, and how to ensure you don't erase more—or less—data than you intend.

ERASE WHAT YOU DO IN WINDOWS

Recently opened files and programs

The logical place to start when removing details of your Windows activities is the Start menu, which shows anyone who uses your PC the programs you've recently added and those you use most often. Windows 11's Start menu also lists Recommended items, including recently opened files.

Further information about what you've been doing is revealed by the Jump Lists that open when you right-click the taskbar or Start-menu icons for programs and File Explorer. These list files, folders, and links you opened recently or use frequently, so you can access them quickly, but they also compromise your privacy by letting others access those items.

In Privacy Eraser, you can wipe this data in the Windows Explorer section of the Windows tab (see screenshot above). Select the options Start Menu Recent Items and Taskbar Jump Lists before you run a clean-up with the program. It's also worth ticking the boxes for the following: Windows Search History, to stop anyone from seeing which items you've searched
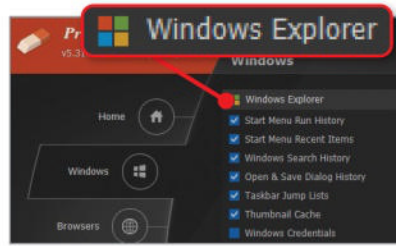
Delete recently used histories to stop people seeing which files you've opened

for; Start Menu Run History, if you've used the Run tool in Windows to access private files and folders; and 'Open & Save Dialog History', to delete the file history from the Open and Save dialogue boxes.

PrivaZer also lets you delete details of recently opened files and programs. Click 'Scan specific traces' on the home screen, choose 'Software use', and select 'Start JumpLists, Quick Access'. Tick the box next to 'Start menu' to wipe usage data from the menu and the taskbar, then choose the Jump Lists you want to delete, such as for Windows Explorer (File Explorer), specific programs, or all Jump

Lists on your computer. Select 'Windows history' to remove details of your recent searches, Run history, and the files and directories (folders) you've used.

Hidden data stored in Windows

One of Privacy Eraser's greatest strengths is that it wipes personal data from Windows you may have forgotten about but that can still be accessed by other people. For example, you may have copied sensitive information to the Clipboard that anyone can then paste elsewhere by pressing Ctrl+V. If they're particularly nosey, they can press Windows key+V to open your Clipboard history and see the last 25 items you've copied. To stop this happening, select Clipboard in the Windows System section of the Windows tab to erase your Clipboard history.

It's easy to forget that files and folders you delete are usually sent to the recycle bin rather than removed from your PC. Ticking the Recycle Bin option in Privacy Eraser empties the bins on all the drives connected to your computer, so their contents can't be retrieved.

PrivaZer goes even further by overwriting files deleted from the recycle bin to guarantee 'permanent deletion without any possibility of recovery'. Click 'Delete without a trace' on its home screen, select 'Empty recycle bin (without a trace)' then select 'See advanced options'. Click the dropdown menu to specify how many times to overwrite recycle bin data—PrivaZer suggests three 'passes' are enough to make recovery impossible (see screenshot below)—then click Start.

You can set the program to always empty your recycle bin after a clean-up by choosing Options on the home screen and clicking Next until you reach the 'Yes, at each cleanup of my PC with PrivaZer' option under 'Empty recycle bin'.

How to use Privacy Eraser and PrivaZer

Privacy Eraser and PrivaZer have very different interfaces but work in a similar way. You can perform an initial scan from both home screens using their default settings—just click the big red Scan button in the former (see screenshot 1) and 'Scan in-depth in 1 click' in the latter 2. Once the scan is complete, click either Quick Clean or Clean to remove all privacy traces, junk files, and other unnecessary elements in one fell swoop.

The drawbacks to this method are that full scans and clean-ups take a long time and they may remove more or less data than you originally intended to. This makes it useful to know which boxes to tick or untick among the privacy options offered by both tools.

Privacy Eraser is the more user-friendly of the two programs, sensibly organizing its options into tabs such as Windows, Browsers, and Applications. PrivaZer offers more deep-cleaning features, but it's not always obvious where to find them because they're located in sections such as 'Scan specific traces'. However, it does let you click Options to specify whether you're a Basic or Advanced user and tailor its settings to your needs.

Both tools are free to use, though Privacy Eraser restricts a few options to its paid-for version, which costs $20 a year. Other than targeting the same areas of your PC, the two programs don't clash so you can either switch between them as required or choose the one that works best for you.
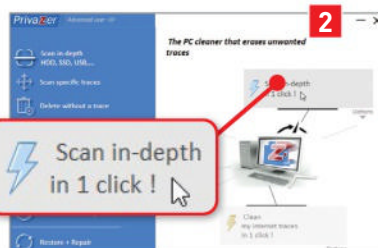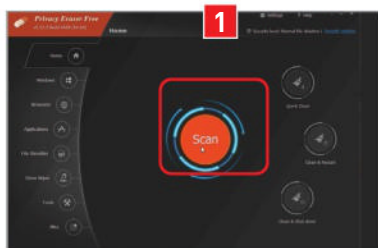
PrivaZer empties your recycle bin and overwrites files so they can't be recovered.

Traces of data in free drive space

When you delete a file from your PC, all that's actually removed is the reference to that item in the Windows master file table (MFT). The file itself remains on your hard drive until it's overwritten with new data, though the space it occupies is now marked as 'free' by Windows. This is useful if you need to 'undelete' the file using a specialist recovery tool such as Recuva or WinfrGUI, but it also means that your hard drive contains invisible data that potentially compromises your privacy.

PrivaZer helpfully provides a dedicated option for removing junk traces from 'free' disk space. On its home screen, choose 'Scan specific traces', select 'Residual traces of old files' under 'Which traces', then select 'Residual traces of old files' on the following screen. Tick the boxes for Pre-analysis and 'Traces in free space' (**1** in our screenshot above right), then click the Scan button.

PrivaZer will identify sectors of your hard drive that contain traces of old files and need to be 'reset to zero'. Click 'See cleanup options' **2** to specify how many times to overwrite the free space—again, three 'passes' is enough—then click the 'Free space' tab and choose 'Smart cleanup' – this is much faster than 'Normal cleanup' because it only cleans necessary sectors. Go back to the previous screen and click Clean **3** to completely erase all the invisible data from your PC.

Broken shortcuts to deleted files

Shortcuts that no longer work because the files, folders, or programs they point to have been deleted are usually more of an annoyance than a privacy concern. But the shortcuts' file names may be enough for others to deduce the contents of the original items and wonder why they were removed, so it's wise not to leave them behind when you delete other programs.

Use PrivaZer to thoroughly delete all traces of data from 'free' space on your PC.

Privacy Eraser makes detecting and deleting broken shortcuts easy—simply go to the Windows System section and tick the boxes for Invalid Start Menu Shortcuts and Invalid Desktop Shortcuts before running a scan (see screenshot right).

In PrivaZer, select Options on the home screen, click Next twice, and choose 'Yes, remove invalid shortcuts' or 'Yes, invalid shortcuts + list of most used' to delete details of frequently used programs.

Leftover traces in the registry

Every time you uninstall a program or change something in Windows, redundant settings get left behind in the registry. Over time, these leftovers build up and slow your PC, and removing them can both speed it up and protect your privacy from anyone hunting for leftover traces.
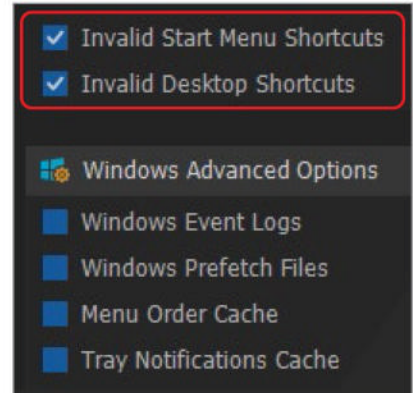
Delete invalid shortcuts to avoid revealing details of removed files.

Deleting registry files yourself can be risky, but Privacy Eraser's Windows tab makes the job easier by letting you select items that it's safe to remove. Options include Obsolete Software, which wipes registry entries for programs you've uninstalled; and Shared DLLs, which deletes old entries for dynamic link libraries that no longer exist.

Privacy Eraser backs up your registry before making any changes and lets you restore it by clicking the three-dot icon next to the Registry heading, then the Restore tab. Select a registry backup and click Restore (see screenshot left).

To clean the registry in PrivaZer, click 'Scan specific traces', choose In Registry, and select Registry. Click 'Save registry' in the bottom-right to create a backup before scanning for leftover traces—leave the pre-ticked options as they are.

Privacy Eraser backs up your registry automatically before making any changes.

ERASE WHAT YOU DO ON THE WEB

Tracking cookies from your browsers

All the main web browsers now offer protection against website cookies by allowing you to either block them all (which can stop some sites from working properly) or block only the tracking variety from third-party sources. But removing cookies that have already been planted on your PC, or have slipped through your browser's net, is less straightforward, particularly if you want to keep 'good' cookies that sign you into websites but delete 'bad' ones that follow you around the internet. If you use several browsers, this task becomes even more difficult.

Fortunately, help is at hand from Privacy Eraser, which simplifies the process of wiping unwanted cookies while keeping useful ones. Click the Browsers tab to see options for all the browsers installed on your computer—or at least the most popular ones, including Chrome, Edge, Firefox, Brave, Opera, and Vivaldi.

The Cookies box for each of these should already be ticked, and when you click the three-dot button next to it (**1** in our screenshot above right), the Cookie Manager will show you a list of all the cookies installed in that browser **2**. Select all those you want to keep to stop the related websites from logging you out, then click OK to confirm. If you're still unsure, click the 'Automatic keep' button **3** to let Privacy Eraser decide for you, though it mainly chooses cookies for webmail services.

PrivaZer's cookie-cleaning works differently by listing them all in one place, rather than organizing them by browser. This makes it easier to decide which cookies to retain and which to remove, especially when they appear in several browsers. To access this option, click 'Scan specific traces' on the home screen and choose 'Internet activities'. Select 'Cookies, Super/Evercookies' under 'Select scans' (super cookies let websites identify your browser and are harder to
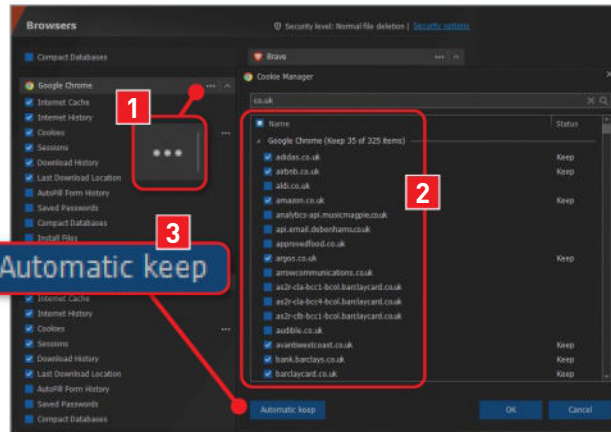
Privacy Eraser lets you decide which browser cookies you want to keep and which to delete.

Carry out precise cleaning of your browsing data by selecting specific options in PrivaZer.

remove than standard ones), then click 'See cookies'.

In the Cookies box that opens, choose Manual to select which cookies to keep and remove—those in the 'To delete' list on the right (see screenshot below left) are most likely to be tracking cookies. Click the 'Show all' dropdown menu to filter cookies by type and browser, or select Smart to save cookies related to specific companies. Once you've made your selection, go back to the previous screen and click Scan then Clean to remove all unwanted cookies.

Browsing history and internet cache

Anyone who wants to know which websites you've visited and when can instantly find out by pressing Ctrl+H to view your browser's History. It's the biggest potential privacy leak on any PC, but few of us bother to regularly clear our histories to cover our online tracks. Websites stored in your History auto-complete when you start typing their URLs into your browser's address bar, which makes them quicker to revisit but also reveals details of your web activities.

As you'd expect, Privacy Eraser's Browsers tab includes the option to delete your Internet History from all the browsers you have installed. You should also tick the boxes to wipe the following: Internet Cache, which is the temporary internet files folder that contains copies of images, videos, and other content from pages you have visited; Sessions, which keeps logs of the sites you have visited; and Download History, which stores details of files you have downloaded from the web. Note that deleting your Download History only removes the list of downloads from your browser, not the actual files themselves.

PrivaZer adopts a similar approach to deleting your browsing history and other details of your internet activities, but it is able to perform a deeper and more precise clean than Privacy Eraser. Click 'Scan specific traces' then 'Internet activities' and select 'Internet browsing' (**1** in our screenshot above).

Click the relevant link for your browser, such as 'Firefox, Pale Moon, LibreWolf', or 'Chrome, Edge (Chromium), Brave, Vivaldi' **2** to choose from a long list of data-deletion options. These include 'Visited sites', 'Typed sites' (URLs you manually entered into the address bar), 'Visited links' (those you clicked on web pages), 'Media cache' (including images and videos), and 'Downloads history'.

We particularly like that you can remove saved search queries from your browser, both from its search box or address bar and from the websites for Google, Bing, and Yahoo. You're likely to be surprised by the number of internet traces PrivaZer finds when you click Scan —it was nearly 77,000 on our PC—but these can all be deleted with a single click.

Saved passwords and form data

Storing passwords and other personal information in your browser, including
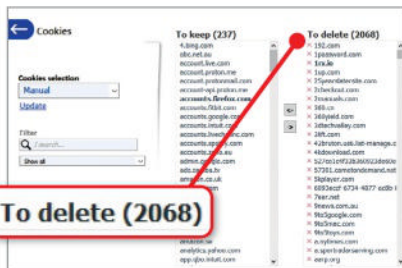
PrivaZer suggests which cookies to delete —these are mostly tracking cookies.

your address, phone number and payment card details saves you a lot of time when signing into websites and filling in online forms. But although it's convenient to auto-fill these details, the fact they aren't encrypted makes them available to anyone who has access to your device or user profile.

Manually removing this data from all your browsers will boost your privacy and security, but it's also a bit of a hassle, which is where Privacy Eraser comes in handy. Simply tick the boxes AutoFill Form History and Saved Passwords (see screenshot right) for each of your browsers to delete the information in your next clean-up. This will prevent the data from auto-filling but also stop it from being stolen and reused. Click 'Yes' if the program warns you that all your saved passwords will be cleared.

In PrivaZer, delete 'Saved passwords' is in the 'Internet browsing' section. Select 'Typed info' to remove other auto-fill data. Alternatively, click the Options button on the home screen and click Next until you reach the 'Internet browsers—Autocomplete histories' screen. In the 'Remove autocomplete histories' section, choose 'Yes (recommended for privacy)' to delete saved form data.

ERASE WHAT YOU DO WITH YOUR SOFTWARE

Traces of your software usage

Browsers aren't the only programs that keep track of your recent activities. Other software stores details of the documents, images, videos, and other files that you've opened, edited, played, and saved. This information can be easily viewed by anyone else who uses your computer. For this reason, it's a good idea to regularly wipe personal data from the tools most likely to compromise your privacy.

Privacy Eraser provides plug-ins for more than 200 popular programs that remove all traces of your usage by performing clean-ups without changing other settings. Click the Applications tab to view available plug-ins for programs and Microsoft Store apps installed on your PC. Our list included 7-Zip, Microsoft Office, Paint.NET, TeamViewer, and Windows Defender, but yours will vary.

Select a plug-in, right-click it, and choose Quick Clean, and Privacy Eraser will run a set of cleaning tasks for that program. These target files, folders, and registry keys that reveal details of what you've been doing. You can also click the Custom tab to create your own plug-ins, though this requires you to know the exact items you want to clean. You should always close the relevant program before running its plug-in or the data may not be properly removed.

In PrivaZer, you can access the same software-cleaning feature by choosing 'Scan specific traces' and then 'Software use'. Programs are organized into categories such as Downloaders, 'Video, music software' and 'Other software'

(**1** in our screenshot right). PrivaZer will automatically detect which tools you have installed. On our PC, it recognized more software than Privacy Eraser managed, including IrfanView, Thunderbird, and VLC. Click the Traces link **2** after running a scan to see details of the files, folders, and registry keys that will be cleaned.

Unwanted software —in one click

One feature offered by Privacy Eraser but not by PrivaZer is an uninstaller, which lets you go further than just wiping details of your software activities by removing programs completely.

Although you can do this using Windows' uninstaller or a third-party tool such as BC Uninstaller (www.bcuninstaller.com), it's a useful additional option for purging your PC of unwanted junk—and stops people from knowing that you've used a certain program.

To access the uninstaller, click the Tools tab (**1** in our screenshot right) on Privacy Eraser's home screen and select Uninstaller in the top-right corner **2**. This will display an alphabetical list of all the programs you have installed. You can reorder these by install date or size by clicking the appropriate column heading or searching for a specific tool.

PrivaZer can clean and remove all details of software usage.

Select a program you want to remove from your computer and click the Uninstall button **3** to open either the software's own uninstaller or the Windows tool. Once you've got rid of the unwanted software, scan for and wipe any leftover traces.
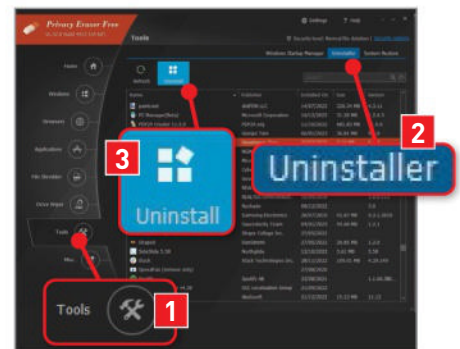
Privacy Eraser's Uninstaller makes it easy to remove all unwanted software.

SECURELY ERASE FILES AND DRIVES

Private files and folders

As well as performing system-wide clean-ups of leftover traces, Privacy Eraser and PrivaZer can also securely delete specific items. This is useful for erasing confidential documents, personal photos, and private videos from your PC, to ensure they can't be recovered. As we mentioned earlier, when a file is deleted in the usual way, its contents remain available until its data is overwritten, along with details of its name, modification date, and location. Only thoroughly 'shredding' the sensitive item will prevent this data from falling into the wrong hands.

To securely erase files and folders in Privacy Eraser, click the File Shredder tab on the home screen. Click 'Add files' or 'Add folders' to select the items you want to delete—you can add several of each to the queue—then click Start to 'shred' them. The catch is that the free version of Privacy Eraser only overwrites data once. When you click 'Security options' to increase the number of passes, you'll be prompted to upgrade to the Professional Edition. Extra security options including 'Scramble file/folder name' and 'Reset file size to zero' also require a paid-for license, which is annoying but one of the few restrictions in an otherwise excellent free program.

In PrivaZer, you can shred files and folders without limitations by clicking 'Delete without a trace' on the home screen, then either 'Sensitive files' or 'Sensitive directories'. Select the item you want to delete—press Ctrl+A to choose more than one – then click either Open (for files) or Select (for folders).

When PrivaZer's 'Delete without leaving a trace' window opens, click 'See advanced options' (see screenshot above)

to choose how many passes it should perform when overwriting data. These go up to 35 but, as we mentioned earlier, three passes are sufficient to make data impossible to recover. Click 'Start' and PrivaZer will thoroughly shred the item, including all references to it in the MFT and leftover traces in free drive space.

Entire hard drives and USB sticks

If you plan to sell or recycle your PC, it's essential to completely wipe its contents to remove every trace of personal data and ensure it can't be recovered. This is also important if you have sensitive information stored on removable media such as a USB stick.

Privacy Eraser includes a Drive Wiper for this purpose, but it's restricted to the paid-for version—although you can

PrivaZer shreds sensitive files and folders to make them impossible to recover.

choose the option, the button to start wiping is greyed out in the free edition.

PrivaZer won't erase everything on a drive, such as programs, documents, and photos, but it will remove all leftover traces of your files and activities once you've formatted the drive yourself. Or you can use it to clean elements that compromise your privacy on devices you share with other people.

Click 'Scan in-depth' on PrivaZer's home screen and select the drive you want to wipe—this can be your main hard drive, an external SSD, a USB stick, an SD card, a NAS drive, and even an MP3 player. The cleaning options available under 'Select scans' will depend on the device, but for a comprehensive scrub just choose 'Select all'. Click 'Scan' to analyze the drive for traces, then click 'See cleanup options'.

Select 'Secure deletion' in the dropdown menu (see screenshot below) and specify the number of passes to perform when overwriting data. Click the 'Free space' tab and choose 'Normal cleanup' to ensure every 'free' sector of the drive is wiped, then go back to the Scan screen and click Clean. PrivaZer will then securely erase your drive of all privacy traces—this may take a long time depending on the size and contents of the drive. You can click Pause or Stop at any time, and click Modify to lower the priority of the cleaning process so that it uses fewer system resources and doesn't slow down your PC.
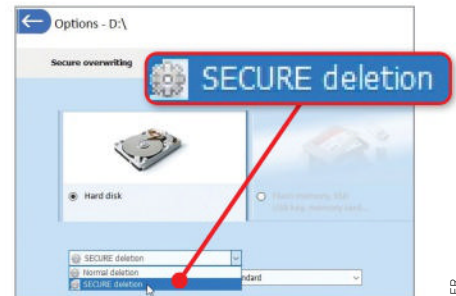
PrivaZer can securely erase all privacy traces from a hard drive, SSD, or USB stick.

Should you pay for privacy cleaners?

Unlike many free privacy tools, Privacy Eraser and PrivaZer don't nag you to upgrade to their paid-for editions, though there are some benefits to doing so. As mentioned above, buying a license for Privacy Eraser, which costs $20 per year, unlocks its Drive Wiper and the full set of security options for deleting files. You also get free '24/7' technical support and automatic updates when new versions of the program are released.

The only notable features missing from the free version of PrivaZer are

the cleaning of Shellbags, which are registry files containing data about the size, position, and icons of folders, and automatic clean-ups of data. Upgrading to the Donors version for the amount of your choice, from $10 upward, will unlock these options along with automatic updates and the ability to scan and clean from the command line.

However, in both cases, the free versions of the programs will be more than sufficient to erase personal data from your PC.

REMOVE EVEN MORE JUNK FROM YOUR PC
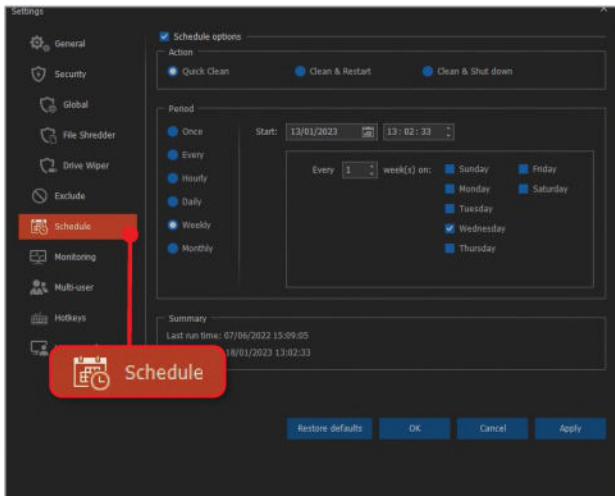
Privacy Eraser lets you schedule your clean-ups for a date and a time that suits you.

You can set Privacy Eraser to clean all your browsing data automatically.

Schedule clean-ups for convenient times

Both Privacy Eraser and PrivaZer let you schedule clean-ups, using the settings you specify and taking place at a frequency and time that's convenient for you, such as when you're not using your PC.

In Privacy Eraser, click the Settings button in the top-right, choose Schedule (see screenshot above left), and tick the 'Schedule options' box. Select how frequently you want Privacy Eraser to delete private data from your PC—weekly or monthly is fine—then specify when to perform the clean-up and click Apply.

In PrivaZer, click Scheduled on the home screen then use the dropdown menus to specify the frequency, day, and time of the clean-up. Select which drive(s) to clean, click Setup to choose the private data you want to wipe, then click OK to

confirm. You can create several scheduled tasks to perform different clean-ups for drives at specific times.

Shut down your PC after cleaning

Full clean-ups in both programs sometimes take longer than an hour, which means you need to wait around to turn off your PC afterward. To save yourself time and electricity, you can have either tool shut down your system automatically once it's finished cleaning.

To do this in Privacy Eraser, either click the down arrow next to Quick Clean after performing a scan and choose 'Clean & Shut down', or click that button on its home screen. You can also click 'Clean & Restart' to delete files that require you to reboot your PC to fully remove them.

In PrivaZer, click 'Shut down PC after cleaning' (see screenshot below left) in the bottom-left corner of a Scan screen to select that option in the menu that opens. Additional options include 'Restart PC after cleaning', 'PC in sleep mode after cleaning', and 'Play a song when completed'—a new feature in the latest version.

Perform automatic data clean-ups

To ensure that private data never remains on your PC for longer than it needs to, you can set your privacy cleaner to delete it automatically. As mentioned before, PrivaZer

only offers this option in its paid-for Donors version, however, Privacy Eraser provides it for free.

Click 'Monitoring' in the program's Settings and select System Monitoring. Tick the 'Browser monitoring' box to erase details of your internet activities each time you close your browser. Select the browser you want to clean and choose an action from the dropdown menu, such as 'Automatically clean with notification' (see screenshot above right). Tick the 'System monitoring' box to clean your PC using your default settings when private data is consuming a specific amount of disk space.

Add cleaning options to your right-click menu

Rather than open Privacy Eraser or PrivaZer every time you want to erase private data from a drive or folder, you can add their cleaning options to your right-click menu. Open the Settings page in the first tool and click General, then tick the box that says 'Add "Secure Erase with Privacy Eraser" option to Windows Explorer context menu'. You can also add the option to the right-click menu for your recycle bin.

In PrivaZer, choose 'Advanced options' on the home screen and click the General tab. In the 'Installation of contextual menus' section, select 'For drives, storages', 'For files', and 'For directories' to add a 'Delete without a trace' option to the right-click menus of drives, files, and folders. You can also add an 'Empty without a trace' option to your recycle bin's right-click menu. ⏻
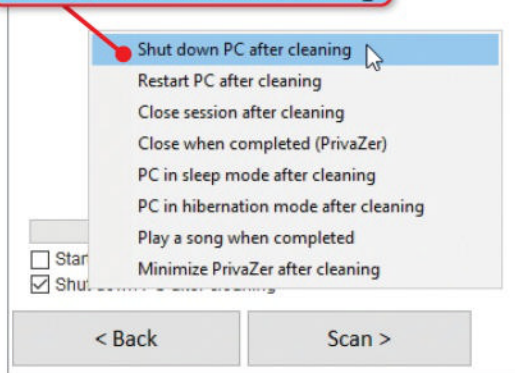
Set PrivaZer to shut down your PC automatically once it has finished cleaning.

CENTERFOLD

XGIMI Horizon Pro

PROJECTORS HAVE COME a long way in a short time. Long gone are the days when they required expensive, fragile bulbs and a roll-down screen. Using a projector as your main source of media consumption isn't such a crazy idea these days—it's become a viable option for lots of people. There are also benefits to using a projector over a standard television—the screen size can be adjusted to suit your surroundings; you can indulge in a spot of childhood nostalgia; and they are just flipping cool. The picture quality is now also so impressive that they've closed the gap even on high-end TVs.

XGIMI already has a plethora of impressive projectors that combine great functionality, ease of use, and lots of features into a well-built, all-in-one media masterpiece. Take the Halo+ model we reviewed in our May 2022 issue. The portable 1080p variant had a lot going for it. This Horizon Pro takes all that was great about the Halo+ (minus the portability) and buffs it up. The Horizon Pro is a 4K resolution 120-inch DLP model with a superb built-in Harman Kardon speaker, solid build quality, sleek design, and up to 30,000 hours of life—that's roughly 3.5 years if you leave it on constantly, or around 16.5 years with a more realistic usage of up to five hours a day. Whatever the chances of you holding on to tech for that long, this projector boasts tons of features and comes packaged in a premium, user-friendly shell. It looks like it's a projector worth shining a light on. **–SAM LEWIS**

1 EYE OF THE STORM

The main draw of this projector is its lens. This LED-powered bulb has a brightness of 2,200 ANSI lumens, which ensures that you'll be able to see the screen even if your viewing room isn't completely dark. It has plenty of color correction adjustments and settings you can adapt to your room. The clarity is fine for a projector, the colors pop, and there's great contrast too. Even when the screen is stretched to its 120-inch limit at 4K, it can bring a real cinema experience to your home.

2 LET ME ENTERTAIN YOU

The XGIMI Horizon Pro has connectivity options to connect external devices, including HDMI and USB, but this can also be done using the built-in Android TV OS. A small and easy-to-use remote with Google Assistant is included, making it easy to access your favorite shows from the comfort of your couch. You can even cast media from your phone or tablet via Chromecast. Apps can be downloaded from the Google Play store, with lots to choose from, making for the perfect media center.

3 INTELLIGENT SCREEN

Intelligent Screen Adaption (ISA) is XGIMI's technology that eradicates the issues you may encounter with other projectors when it comes to setup. This includes features such as intelligent screen alignment, autofocus, auto keystone correction, and intelligent obstacle avoidance. All of these AI tools help make setting up the projector a breeze, meaning that you can place this in lots of different places and still get a great image from your living room to your garden.
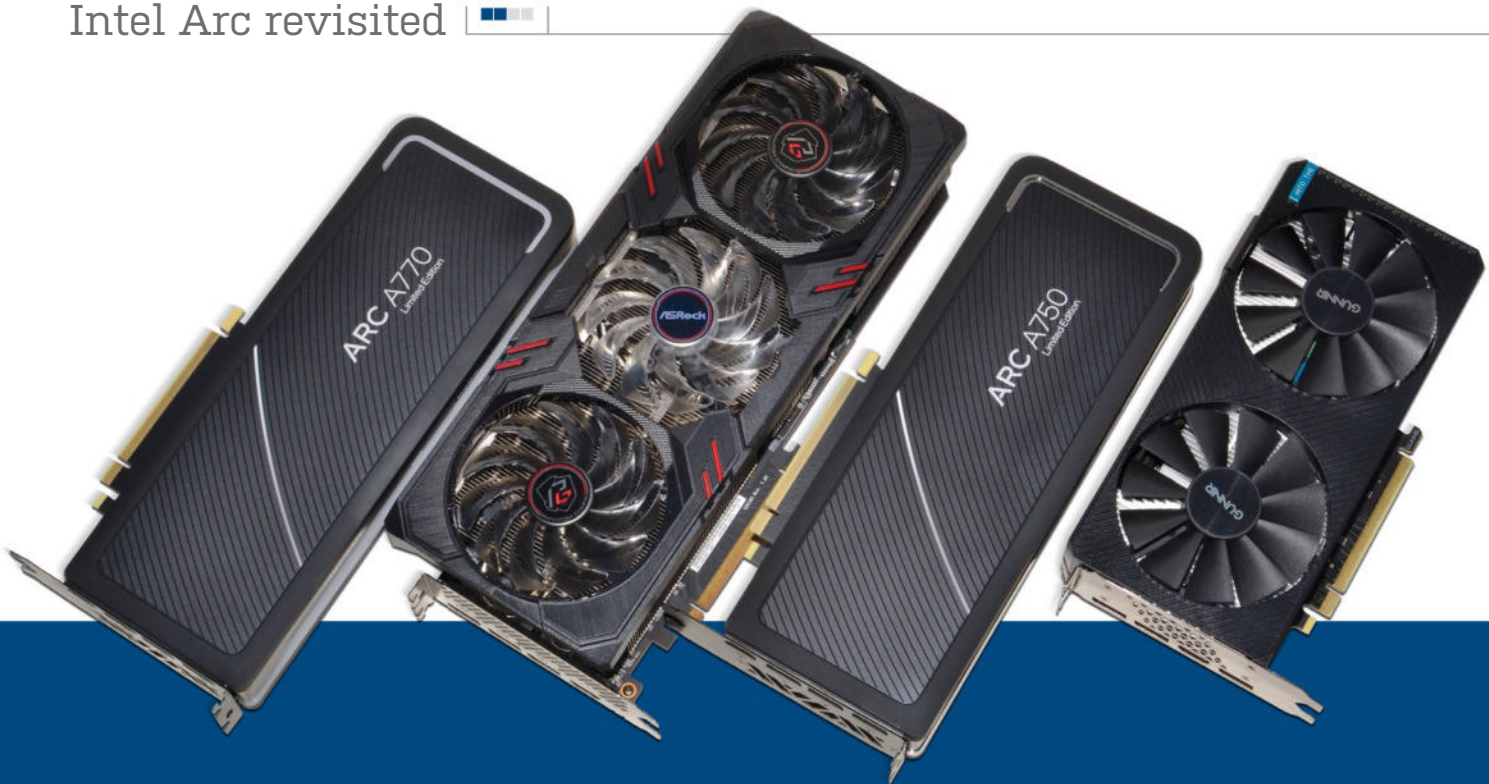
INTEL ARC REVISITED

BY JARRED WALTON

Lots of driver updates in four months

INTEL'S ARC GPUs officially launched at the end of 2022, though the exact launch date for some models is hard to nail down. The A380 first appeared in China in the spring, but it wasn't available to purchase in the US until August. The faster A770 and A750 cards launched in October, but it was another six weeks before the A770 8GB could be found.

We've talked about the fundamentals of the Arc Alchemist architecture (see Holiday 2022 issue), and all our Arc graphics cards reviews over the past few months (including the ASRock A770 8GB this issue, page 76) have mentioned drivers as a potential pain point. But Intel says things have improved a lot over the past four months and claims significant performance gains with the latest drivers.

Challenge accepted! We set about re-testing every Arc graphics card on the original 3490 launch drivers (the A380 was first available with the 3259 drivers, but we opted to stick with the 3490 drivers from the A770/A750 launch) and then re-tested every card with the latest 4123 drivers. Let's see how much has changed.

PLUGGING THE HOLES

Arc arrived with arguably the best GPU drivers Intel has ever created, but that's not saying much. A few years ago, it wasn't uncommon to see games refuse to work on Intel's integrated graphics solutions—and even those games that did often performed poorly. Intel's DG1 (see sidebar) helped pave the way for more frequent driver updates, but things were still iffy back in 2021.

Since the first dedicated Arc A380 cards started showing up in China, which meant they also started getting shipped around the world, Intel has been cranking out updated drivers on a regular basis. There are presently 11 different versions of Arc drivers available from Intel, five WHQL (Windows Hardware Quality Labs) certified and six beta drivers, but there were at least five other 'hotfix' or beta drivers that are no longer listed.

Many of the updates have been targeted at one or two specific games—for example, two different drivers addressed problems with *Spider-Man Remastered* around the time that game launched. Other updates have had much further reaching ramifications, with the biggest change being DirectX 9 optimizations.

DIRECTX 9, 20 YEARS LATER

Microsoft's DirectX 9 API became publicly available back in 2002, but it continues to see quite a bit of use even today.

Opposite: **Intel's Arc A-Series lineup currently consists of four desktop cards, (from left to right) the Intel A770 16GB LE, ASRock A770 8GB, Intel A750 LE, and Gunnir A380. The A580 remains in limbo.**

Some of that goes back to the venerable Valve Source engine used for *Half-Life 2*, which saw widespread adoption for various mods and spinoff games including *Counter-Strike: Global Offensive*, *Left 4 Dead 2*, and *Team Fortress 2*.

Considering how old the API is, it's easy to understand Intel's decision to focus on modern [DX12 and Vulkan] APIs for the launch of Arc graphics cards. Most recently released games use DirectX 12 or DirectX 11, or sometimes Vulkan. Why put lots of effort into trying to optimize the drivers for older games? The problem is that on the PC, a lot of older games remain popular. Token support for DX9 via DX12 emulation might have sounded fine on paper, but it was a glaring indication that Intel's GPUs and drivers weren't as good as AMD and Nvidia drivers.

The solution Intel came up with was to leverage more translation layers to turn DX9 API calls into either DX12 calls or Vulkan calls. The DX12 emulation comes from Intel's own internal work on the drivers, or perhaps Microsoft's own D3D9On12 mapping layer. This is what was used for the initial launch drivers. But more work was put into the DX9 emulation with Arc's December driver update.

The major change appears to be the use of DXVK (DirectX to Vulkan) from Steam for 'some cases'. Intel hasn't detailed exactly which games use DXVK and which use DX12 emulation but, whatever the changes, frame times and average performance have increased substantially. That's great news if you want to buy an Arc GPU for a modern PC to run old games. Remember: PCIe Resizable BAR is basically required for Arc GPUs, which generally means you generally need a 10th gen or later Intel CPU, or Ryzen 5000 or later AMD CPU. Otherwise, you'll lose about 25 percent of the potential performance, based on testing. Or you could just buy an AMD or Nvidia GPU.

ARC PERFORMANCE UPDATE

Given all the changes, we pulled out 15 different games, including two DX9-based ones, to check how the various cards perform. All these tests were done using the same PC that we used for the previously published Arc GPU launch reviews (see "Looking Back…" sidebar), which is a different can of worms. Let's start with the high-level overview and then discuss some of the anomalies.

DEDICATED GRAPHICS, ROUND TWO

Intel first announced its intention to create a modern dedicated graphics card back in November 2017, when it hired Raja Koduri shortly after his departure from AMD. This wasn't going to be a quick and easy task, though the initial plan was almost certainly supposed to be something competitive before 2022. And there was a precursor to Arc, even if most people never saw it.

First shown off at the start of 2020 during CES, Intel's DG1 test vehicle (Discrete Graphics 1) felt more like a way to drum up hype rather than something substantive. The hardware started shipping, in a limited fashion, in mid-2021, with cards from Asus and Gunnir. The hardware basically consisted of the integrated graphics used in Intel's 10th Gen Tiger Lake mobile processors, minus the CPU and with dedicated VRAM. But Intel opted to stick with LPDDR4x, the same memory used by the laptop processors.

You also needed to use one of only a handful of motherboards that had the necessary BIOS firmware to support the card—the boards used B560, B460, H410, B365, or H310C chipsets and supported 10th Gen Comet Lake or 11th Gen Rocket Lake CPUs. The DG1 cards

generally weren't sold as standalone cards, so the only way to get one was to buy a complete pre-built PC.

How did it perform? In a word, poorly. It was roughly on par with Nvidia's GT 1030 GDDR5 graphics card, an anemic solution that launched in 2017, cost $69, and wasn't fit for much more than 720p minimum quality gaming. It was also about as fast as AMD's Vega 8 integrated graphics found in Ryzen 4000 U-series (15W) processors. But it was a start.
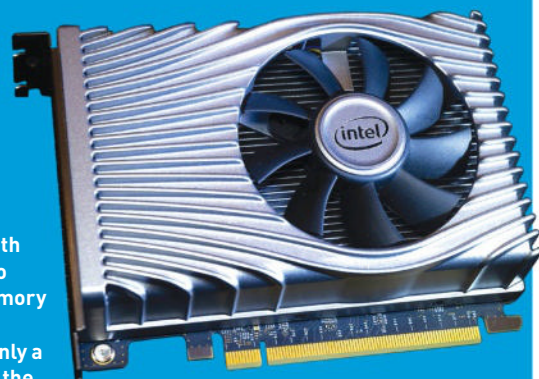
Intel DG1 was the first 'modern' discrete graphics card produced by Team Blue, but it was a weak pretender. Arc Alchemist GPUs are also referenced as DG2 in Intel's drivers.

First, we saw average performance gains ranging from 5 to 11 percent, depending on the card. The A770 8GB and A750 saw slightly larger gains than the A770 16GB and A380. The A770 16GB results are easy enough to explain—having twice as much memory as the other A700-class cards means it was less likely to run out of VRAM, particularly at 1440p. Not every game showed performance gains, though in most cases, the dips that were more than a couple of percent are explained by the lack of memory.

The only exception to that is *Control*, which generally doesn't use more than 8GB of VRAM at the selected settings. Both the Intel Limited Edition cards dropped about five percent in performance and as much as nine percent on the A750. *Control* is a ray-tracing game and might
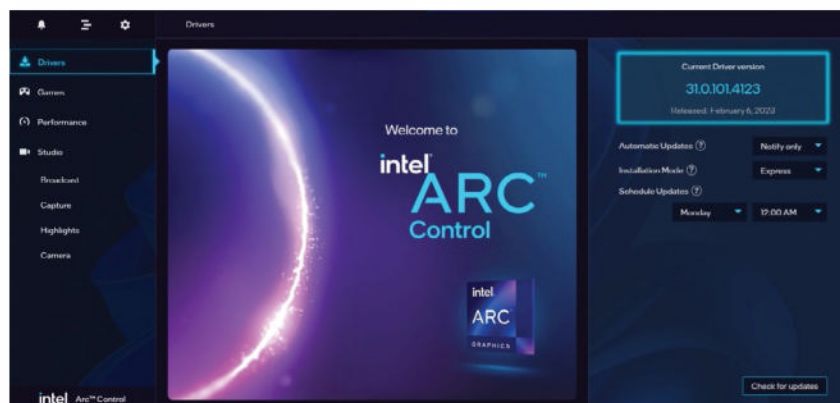
Arc initially launched with more than a few glitches, and Intel's driver team has been busily fixing problems as fast as it could, with about a dozen different versions since October.

LAUNCH DRIVERS VS CURRENT DRIVERS

The difference in performance between Intel's 3490 launch drivers, and the latest 4123 drivers across three of its GPUs. In some cases, performance improves greatly (Mass Effect 2), in some it drops slightly (Control), but mostly there is a small improvement.

Game	Setting	Arc A770 16GB			Arc A770 8GB			Arc A750		
		4123	3490	%Chg	4123	3490	%Chg	4123	3490	%Chg
15 Game Geomean	1080p "Ultra"	73	68	+7%	70	64	+10%	63	58	+9%
	1440p "Ultra"	54	52	+5%	48	46	+5%	45	40	+11%
Bright Memory Infinite (DXR)	1080p Very High	28	26	+7%	23	17	+39%	22	17	+29%
	1440p Very High	16	16	+2%	6	5	+6%	8	6	+41%
Control (DXR)	1080p High	54	56	-4%	59	58	2%	49	52	-6%
	1440p High	33	35	-6%	36	36	0%	30	33	-9%
Cyberpunk 2077 (DXR)	1080p RT-Ultra	30	27	+8%	29	28	+4%	26	24	+9%
	1080p RT-Ultra	20	18	+9%	14	15	-6%	14	10	+44%
Metro Exodus Enhanced (DXR)	1080p Extreme	53	51	+4%	53	52	+3%	47	46	+2%
	1440p Extreme	40	38	+5%	37	36	+3%	34	34	-1%
Minecraft (DXR)	1080p 24 RT Blocks	18	16	+10%	16	17	-5%	15	15	-1%
	1440p 24 RT Blocks	13	13	-2%	13	13	-4%	13	13	-2%
Borderlands 3 (DX12)	1080p Ultra	92	90	+2%	94	93	+1%	86	83	+3%
	1440p Ultra	66	65	+2%	68	67	+1%	62	59	+4%
Counter Strike: Global Offensive (DX9)	1080p Max	355	356	0%	354	326	+9%	357	344	+4%
	1440p Max	333	323	+3%	329	300	+10%	334	286	+17%
Far Cry 6 (DX12)	1080p Ultra	100	98	+3%	97	95	+2%	93	90	+3%
	1440p Ultra	79	77	+3%	76	74	+02%	71	69	+4%
Flight Simulator (DX11)	1080p Ultra	66	66	-1%	65	65	0%	59	57	+3%
	1440p Ultra	47	48	-2%	48	49	-2%	43	42	+1%
Forza Horizon 5 (DX12)	1080p Extreme	82	80	+3%	67	64	+5%	60	57	+5%
	1440p Extreme	71	69	+2%	59	55	+5%	50	48	+5%
Horizon Zero Dawn (DX12)	1080p Ultimate	90	83	+9%	84	80	+5%	78	77	+2%
	1440p Ultimate	77	69	+11%	73	70	+4%	63	63	+1%
Mass Effect 2 (DX9)	1080p Max	294	172	+70%	302	157	+92%	289	167	+74%
	1440p Max	235	158	+48%	252	148	+70%	229	150	+52%
Red Dead Redemption 2 (Vulkan)	1080p Max (no MSAA)	90	90	-1%	90	90	0%	Fail	84	N/A
	1440p Max (no MSAA)	72	72	0%	68	69	-1%	Fail	63	N/A
Total War Warhammer 3 (DX11)	1080p Ultra	63	58	+9%	63	57	+9%	57	51	+12%
	1440p Ultra	42	40	+5%	42	39	+7%	38	34	+10%
Watch Dogs Legion (DX12)	1080p Ultra	74	75	-1%	71	67	+5%	64	62	+3%
	1440p Ultra	58	58	+1%	54	53	+2%	50	45	+12%
Geomean Sans DX9	1080p Ultra	58	56	+4%	55	53	+5%	48	48	0%
	1440p Ultra	42	41	+2%	37	36	+1%	33	32	+2%
Geomean Sans DX9/DXR	1080p Ultra	81	79	+3%	78	75	+3%	70	69	+1%
	1440p Ultra	63	61	+3%	60	58	+2%	53	52	+2%

All testing was done on a Core i9-12900K, MSI Pro Z690-A WiFi DDR4 motherboard, 2x16GB Corsair DDR4-3600 16-18-18 RAM, Crucial P5 Plus 2TB M.2 SSD, Cooler Master MWE 1250 V2 Gold PSU, running Windows 11 build 22621.1265. The latest game updates available were applied and we tested with Intel 31.0.101.3490 and 31.0.101.4123 drivers.

be hitting power limits, while the slightly overclocked ASRock card with higher default power limits doesn't exhibit such behavior. But let's talk about some of the oddities we observed.

First, *Red Dead Redemption 2*, using the Vulkan API, consistently crashed our test PC with the A750 card—and it crashed a different test PC too. It was mostly stable using the original 3490 launch drivers, enough so that we could complete a few test runs before the PC would restart, but every driver we checked had stability issues. Intel replicated the problem, which is limited to the A750. A fix should be available by the time you read this.

Next, Bright Memory Infinite, a ray-tracing title, has a severe memory leak problem. We could complete one benchmark run at 1080p with the Normal preset, but the 8GB cards at 1080p and Very High would go from being somewhat smooth (around 25-30fps) to a stuttering mess about midway through the benchmark, with minimum framerates of 1fps. This is another bug that Intel has confirmed it is working to fix.

Finally, *Minecraft*, also with ray tracing enabled, performs poorly on all Arc GPUs right now. When the cards first launched, you couldn't even turn on ray tracing in the game, as apparently it was coded with a 'whitelist' of cards that support DXR (DirectX Raytracing). An update to the game in December finally allowed the Intel GPUs to run with ray tracing enabled, but the results remain poorer than expected.

As a point of reference, in other demanding ray tracing games, such as *Cyberpunk 2077*, the A770 is only 10 percent slower than an RTX 3060; in *Minecraft*, the RTX 3060 is currently nearly triple the performance. In fact, even the RX 6600 outperforms the fastest Arc GPU by 25 percent, whereas the A770 is 60 percent faster in *Cyberpunk*. Intel has not confirmed the issues with poor *Minecraft* performance… yet. We figure it's only a matter of time.

Interestingly, our DirectX 9 test titles, *CSGO* and *Mass Effect 2*, are a mixed bag. Intel reported substantial improvements in CSGO, to the tune of 75 percent gains. We didn't measure that, but there are some caveats. The first run through a map with the 3490 launch drivers exhibited a lot of stuttering and hitching. Subsequent runs performed better, particularly on the 8GB cards. We're also showing just the average framerates, but the 99th percentile average fps showed much bigger improvements, something Intel also highlighted in its testing. On the other hand, *Mass Effect 2*, a game that Intel didn't include in its own testing, showed
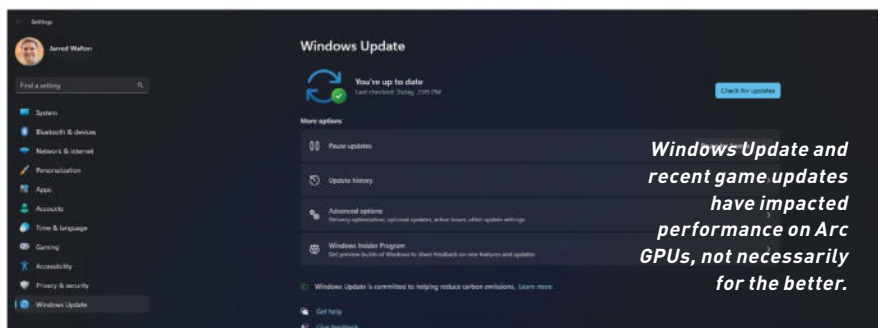
Windows Update and recent game updates have impacted performance on Arc GPUs, not necessarily for the better.

LOOKING BACK AT LAUNCH PERFORMANCE

Our focus was on the performance of Intel's most recent drivers compared to launch drivers, but it's also interesting to look back at our data from the launch. We've seen minor to major updates to several games in our test suite, which means we can't directly compare results today with what we recorded in October, but while you'd hope for continued improvements, reality is a bit harsh.

We never tested the Arc A770 8GB prior to this issue, but the A770 16GB, A750, and A380 all show a lot of performance regressions. The problem is that the games with the biggest changes are also games that had major updates. *Cyberpunk 2077* had a patch to enable DLSS 3 Frame Generation, Reflex, and FSR 2.1. *Flight Simulator* got a patch for DLSS 3 and FSR 2.1, and *Forza Horizon 5*

had an overhaul that added DLSS 2, FSR 2.2, and TAA support. Those all require significant game engine updates, and perhaps some optimizations Intel had for the games got broken, but even smaller updates could cause some changes.

There's also the question of Windows updates and even a system BIOS upgrade affecting performance. The latter was done just to confirm that the older BIOS wasn't somehow affecting performance or stability. For the former, while you can delay critical Windows updates for 30 days and repeat the process every month, eventually it's easier to just cave in.

Overall, we measured a five percent drop compared with launch testing but, given the number of game patches that have happened, tracking down the exact cause simply isn't possible.

large and consistent gains across all the cards and resolutions.

As far as major gains go, it's important to note that the overall increase in performance shown in our table is skewed by the inclusion of DX9 games that buck the trend. Omit those two titles and the overall improvement is less than five percent. Drop the DXR games from the list and the delta drops to under three percent. If we were to test a dozen or more DX9 games, we'd certainly see a lot more that show large performance increases.

INTEL ARC, THE ITERATION GAME

None of our findings are particularly surprising, including the continued oddities. AMD and Nvidia have been playing the drivers game for decades and even they have occasional problems. Intel has had graphics drivers for integrated graphics solutions for decades as well, but the performance on tap was so low there often wasn't any pressure to try to optimize for newly released games. Creating dedicated graphics solutions changes users' expectations, and now Intel is playing catchup.

The most important items with the driver updates coming out of Intel are that there's a regular cadence, and that older DirectX 9 games got some much-needed TLC to get them running more smoothly. It's rare that more than two weeks passes without a new driver being announced, and Intel has also been doing better on getting Game Ready drivers out for bigger launches, like *Hogwarts Legacy* and *Atomic Heart*. If it can keep that up, plus add the occasional overhaul with more universal improvements, in a few years we shouldn't need to even have a serious discussion about Intel's GPU drivers.

Let's hope that Intel's GPU and driver teams get the time they need because, so far, it doesn't sound like many people are biting on Arc graphics cards. Intel just dropped the official price of its A750 Limited Edition card to $249, down $40 or 14 percent from the launch price. Big companies don't do that when parts are flying off the shelves. A lot is riding on the future Battlemage GPUs, though we'll have to wait until early 2024 to see if Intel can narrow the gap between Arc and its AMD and Nvidia competition. ⏻

How do you transmit high-resolution images of exoplanets using an internet connection that's stuck in the 1990s? *James O'Malley* meets an astronomer in Antarctica to find out

THE INTERNET AT THE END OF THE EARTH
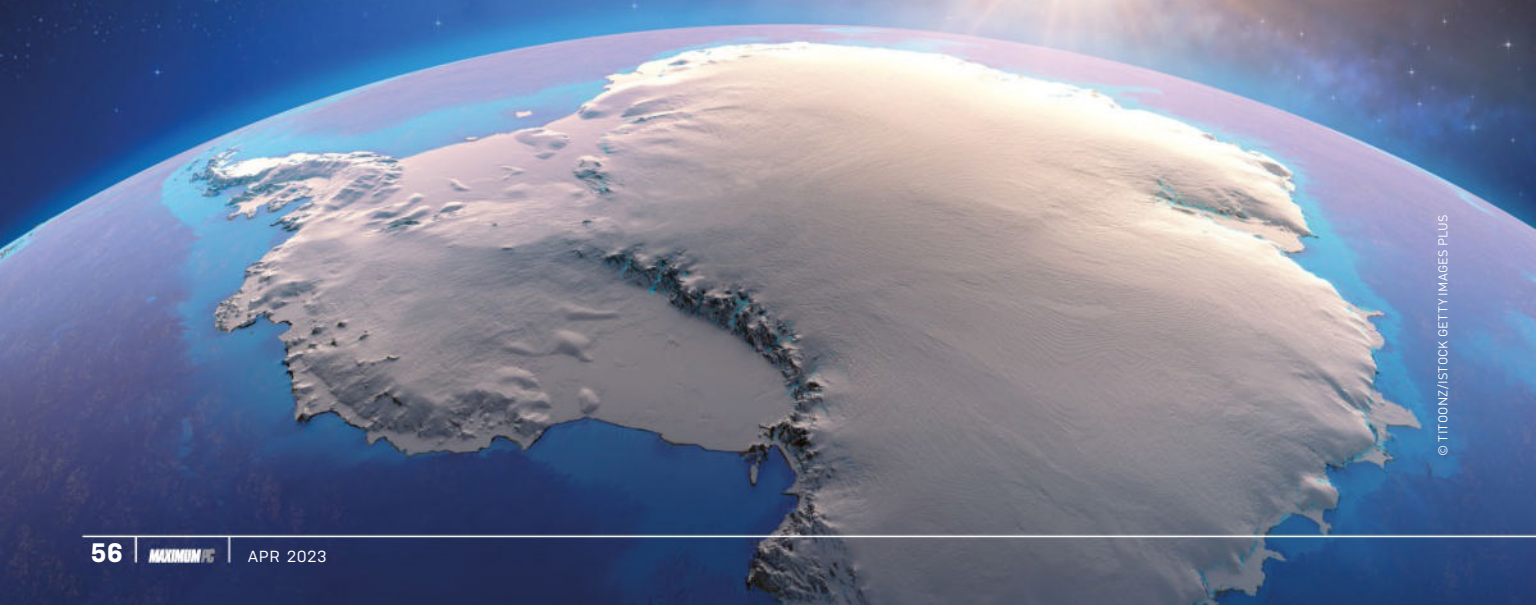
FOR MOST OF US, updating our software requires merely tapping on the app store and watching a progress bar track across the screen for a few seconds. For George Dransfield, however, it isn't so easy. Last summer, she boarded a plane to Hobart in Australia, then after a spell in quarantine, took another flight to Wilkins Aerodrome on the coast of Antarctica. After a bus ride to Casey Station and one final flight on board a tiny Basler turboprop, she arrived at her destination: Concordia Station, which sits 680 miles inland. She had come armed with a couple of portable hard drives and a laptop, with seven weeks to perform some critical software maintenance.

Dransfield isn't an explorer but an astronomer and her mission was to update the software that processes data collected by A-STEP, earth's most remote space telescope. The epic journey was essential because the station lacks decent internet connectivity—and when the telescope's images are 4,096 x 4,096 pixels each, that's a problem.

"We spend the time taking images of the sky, and each image is about 150MB," says Dransfield. "Like most telescopes, you download the raw images to a computer after a night of observing and then you process them yourself."

It's getting the images out of Antarctica that's the tricky bit. The station has an internet connection back to the rest of the world, but it's via satellite and can only reach dial-up era speeds that would have last been considered impressive around 1996. "Our internet connection has recently been upgraded. We can now reach speeds of 80KB per second," says Dransfield. "But we can't get our raw data until someone goes the following year and puts it on a hard drive."

Instead, the systems at Concordia use clever software to analyze images automatically, sending back a snapshot version of the data—a process akin to attaching a low-resolution JPEG instead of a fully-fledged RAW file—over the base's slow satellite connection. It means that scientists back at the University

The South Pole is a challenging environment for scientists.

Concordia Station is not for the faint-hearted.

of Birmingham in the United Kingdom, where she is based, and in other places around the world at least have some data to work with.

PATCHING THE HARD WAY

The specific software Dransfield was sent to upgrade managed the data pipeline, taking the data from the telescope and processing it. It was originally written in IDL, a language that was developed in the 1970s and is similar to Fortran. But before heading south, Dransfield was tasked with rewriting the entire stack in more modern Python.

Unfortunately, updating it remotely was not an option. "If I want to edit maybe five or six lines of code, I need at least an hour," she says. "You're in a terminal, you type a letter, and then it takes two or three seconds for that letter to actually appear. I cannot begin to explain how tedious it is."

But getting the new software installed was important for the telescope to be able to do some science. "They changed the camera so the images that came in this year were different from last year's images," she said. "So I had to do a million fixes to adapt everything."

Even if Dransfield could put up with the dismally slow connection, limited connectivity means only one person can log in to the VPN at once. So it was time to head for the Antarctic. "This is such an enormous piece of software, I couldn't just upload it," she says. "And because I'd written the software, I had to be the one to install it."

Code was written, flights were booked, and she headed to the South Pole for a seven-week mission on

Concordia. But there were other non-geographical obstacles to overcome. "You'd think that with such important operations, people would be careful about everything, but no one could tell me for sure what the specs of the new server were that they had shipped down there," she says. "I needed to test installation on a similar computer, but I didn't know what that was."

Though the code was destined to run on a Linux system, she couldn't be sure exactly which packages and binaries would be running on the destination system. So before she set off, she tested her code on as many different computer systems as possible, including a Raspberry Pi. And this was a necessary precaution because the effective lack of internet connection removed a key tool in every coder's arsenal.

"At home, when something doesn't work, I copy the error message and paste it into the search box, like every other coder, and see what Stack Overflow has to say about it. I couldn't do that there because I didn't have access to the internet," she says. "It was genuinely challenging to do this job without the internet and access to help from other people."

LIFE WITHOUT WHATSAPP

Once Dransfield was on the base, the internet limitations were not just annoying for work but for living, too. "The problem is that the internet they have is needed for essential things," she says. This meant that critical life-support and scientific communications are prioritized.

"I was told off for hogging the bandwidth by being connected for too long," says Dransfield, who had

Telescopes at Concordia gather vital data for astronomers.

Satellites leave visible trails that can impair the images of faraway planets.
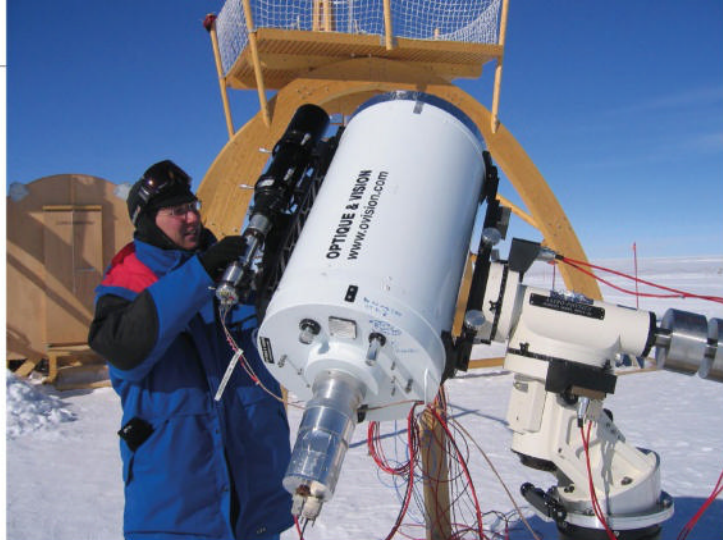
to beg the station's IT manager for more internet time. "He had an app where he could see how much you'd gone over by. You had to say 'sorry' to get reconnected," she adds.

It also meant staying in touch with the outside world was a challenge. "The only thing we all had access to was WhatsApp. Each of us had a limit of 20MB per day and so you had to use that wisely," said Dransfield. When she first arrived, she would recklessly burn through her data allowance, but quickly learned to be more careful. Only on special occasions was she allowed to make a voice or video call.

"There's also what we call the Zoom Room, which is a tiny cabin, with a computer with Zoom and Skype on it, and a headset, and you could go in there for video calls," she says. But the room was used sparingly. "Everybody else had to be cut off from the internet during those meetings."

The personal frustrations are, however, trivial compared to the limitations imposed on the scientific research they can do with such restricted connectivity. "There's so

much more that can be done with our science data," says Dransfield. "We have all these images of the sky and because we are close to the pole, most other telescopes can't see the bits of the sky that we can."

She gives the example of spotting moving objects, such as asteroids or comets, from outside the solar system—but getting the data to the scientists that study them is slow. "There's so much additional science that can be done. But it can only be done once we have the raw data, which we can only collect when we go there."

THE STARLINK DISRUPTION

Concordia is currently stuck with a torturously slow connection, but things may be about to change. In September 2022, SpaceX announced that its Starlink satellite broadband was now available in Antarctica.

What makes it different from the connections before it from the likes of Iridium is that Starlink is a mega-constellation of not a handful of satellites, but up to around 12,000, and almost 3,000 are already in space. This means that each satellite covers a significantly smaller patch of the Earth, so bandwidth isn't shared between so many users. They are also closer to the ground, meaning that latency becomes less of a problem for activities such as video calls.

Given Concordia doesn't have any near neighbors, it's conceivable that if the system was deployed, it could enjoy speeds of between 50 and 200Mbits/sec, roughly equivalent to a high-end home broadband connection, and fast enough to shuffle gigabytes of data around.

Other Antarctic research bases, such as the US McMurdo station, are already trialing the technology.

What difference could it make to Concordia? "That level of bandwidth increase would be transformative," says Dransfield. "It would save me so much time, I'd be able to Secure Shell (SSH) in and make any adjustments I need to make quickly."

It would also mean Dransfield could download raw images more often so that scientific collaborations could happen more easily. "We're trying to take part in things like searching for the follow-up events that happen after a supernova, but they need our raw images," says Dransfield. "This is cutting-edge science but we're like, well, we can get you the images in a year. Starlink would broaden the amount of science that we can do."

Dransfield recently attended a conference of Antarctic scientists, and the enthusiasm for Starlink was palpable. "Most people are just like, yes, Starlink, as soon as it's available, we're going to go for that because we need the bandwidth."

However, of the Antarctic scientists present, only a handful were astronomers—and this gives Dransfield a different perspective on satellite technology. It turns out that despite the enormous bandwidth benefits, she's not a fan of Starlink. "We have a different thing to balance," she says, "because we can see Starlink in our images.

"Filling the night sky with satellites... we're not super keen on that," she adds. "If you look at images from places like other popular observing sites, there's little streaks that you see."

The streaks are the motion trails of satellites in orbit around the Earth, captured because space telescopes take long exposures to capture objects far away in space. "Starlink is going to be putting up loads of satellites and while we want the internet, we don't want them ruining what is one of the most important and unique astronomical sites that we have available by filling it with satellites."

It's a criticism that SpaceX has heard many times before. "I am confident we will not cause any impact whatsoever in astronomical discoveries. Zero. That's my prediction, we will take corrective action if it's above zero," said SpaceX founder Elon Musk in 2020.

Theoretically, it's possible for astronomers to correct their data to account for satellites getting in the way of the telescope. But Dransfield ultimately believes there's a more fundamental problem. "If we know their orbits then we can just correct our images for them, but I think SpaceX underestimates how much additional work that is."

This sort of error correction is already common in astronomy—the satellites and other objects are referred to as 'systematics', and astronomers are used to modifying their data to account for, say, the Hubble Space Telescope moving into view in the skies above. But Starlink is on a different level.

Starlink could bring faster internet, but it's not ideal for astronomers.

"It's an additional systematic error in our data," says Dransfield. "The more you correct your data for systematics, the more it increases the uncertainty on the end result."

She gives the example of detecting a planet in orbit around a distant star. She might try to calculate the size of the planet, but the error bars on the calculation will be wider if the 'systematic' has introduced more uncertainty. "Sometimes we're looking for really small events, like shallow changes in the brightness of a star, and if you can't trust those changes in brightness because you had a Starlink transit as well, then it could end up just ruining so much otherwise awesome data," she says.

Weighing the potential benefits of Starlink against the impact on her work is difficult, but it's a battle she fears she will lose. "Because there's not a lot of astronomy in Antarctica, our voices aren't as important as everybody else who is like, 'Yeah, but we could have internet'," she says.

"As an astronomer with access to Antarctica, I cannot begin to tell you how unique it is and how special what we can do from there is, in our field of searching for planets," says Dransfield. "I would prefer it if they didn't contaminate our skies further because they are so precious." ⏻

THE SEARCH FOR EXOPLANETS

Dransfield focuses on detecting and tracking exoplanets—planets that orbit around stars other than our own sun. The A-STEP telescope can't see the planets directly, in the same way that we can see Saturn and its rings with a sufficiently powerful telescope. Rather, it's a photometric telescope that measures the brightness of the light to detect planets that are light years away from Earth.

The A-STEP telescope measures light to detect distant planets.

The telescope's primary mission at the moment is to follow up on observations made by TESS, the Transiting Exoplanet Survey Satellite, which was launched into space in 2018 by SpaceX. It uses an extremely wide lens to survey 85 percent of the sky to identify potential exoplanets, and it's then up to Dransfield and her colleagues to use A-STEP to make more detailed observations of each identified exoplanet candidate.

"When a planet passes in front of its star along our line of sight, there is a temporary dip in the star's brightness as a small portion of the stellar disk is obscured, and this event is called a transit," she says. It's the characteristics of each transit that tells scientists about the planet. Characteristics such as how long each transit lasts, how deep the transit is, and how long there is between consecutive transits are all indicative of factors such as a planet's size, or how far away from the star it is.

HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH

HIDDEN RIGHT-CLICK MENU

If you use the right-click button in File Explorer to view more options, tasks, or functions, you might not be seeing all the options available to you. You can view a menu with the complete list of options by clicking on 'Show more options' but holding down 'Shift + F10' while selecting a folder or file is a quicker way to access this hidden menu. You can also change the settings so that Shift + right-click brings up the full menu.

MAKE – USE – CREATE
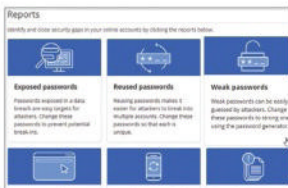
62
Secure all your passwords safely with Vaultwarden.
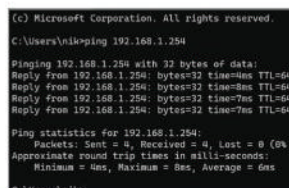
66
Check for lost data packets on your Wi-Fi.

70
Switch to private versions of your favorite software.

SAM LEWIS
STAFF WRITER

MY IDEAL PC CONFIGURATION

I've just wrapped up building the Intel NUC 13 Extreme PC with an RTX 4070 Ti inside—check it out in our previous issue, because that machine rocks! Anyway, this has to be my ideal form factor for a PC—I love tech that can either hide or fit into your living space without standing out.

The Intel NUC 13 Extreme is bigger than the previous gen but it's a minimalistic box with incredible power lurking underneath—an Intel Core i9-13900K, a Zotac Gaming GeForce RTX 4070 Ti Trinity OC, 64GB of Corsair Vengeance DDR5 SODIMM RAM running at 4,800MHz, and an SK Hynix P41 Platinum 2TB SSD.

That's one heck of a list of components in something as compact as this. It's an outright console killer, which it should be for this price, but it also doubles as a great productivity PC for rendering, editing, and designing. If I had the budget, a small form factor PC as good as the Intel NUC 13 Extreme is a route I'd consider.

Talking of which, our budget machines in the *Blueprints* section have gradually crept up in price over the past few months, so we've discussed how we keep these machines in the 'budget' range. With prices rising across the board, we'll aim to offer systems with modern components at an affordable price.

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

Keep passwords safe with Vaultwarden

YOU'LL NEED THIS

PC RUNNING DOCKER
Requires Ubuntu or Windows with the Windows Subsystem for Linux (WSL) enabled

ONLINE ATTACKS ARE on the rise and even your cloud-hosted password manager isn't immune. Recent breaches at Norton Password Manager and LastPass are a reminder that even data secured with the strongest encryption is still vulnerable. Both services were targeted by credential stuffing attacks, which uses stolen username/password pairings from other breaches to bypass security. One solution is to store your passwords offline—either manually entering them each time or switching to an offline password manager with all its extra steps.

We're going to give you all the convenience of a cloud-based password manager, Bitwarden, but without trusting your passwords to a third party's cloud storage. This is done using an unofficial Bitwarden port called Vaultwarden and involves you hosting your own password server. Although we've written this tutorial around the NAS build we featured in the September 2022 issue, you can adapt it to your own ends (see boxout for more details). **–NICK PEERS**

1 OBTAIN DOMAIN

If you want to be able to access your password manager while away from your home network, you'll need to set up a suitable domain. For this tutorial, we're going to make use of a free dynamic DNS hostname courtesy of No-IP.com, but you can use your own domain if you wish by creating a dedicated subdomain for it, which you'll need to pair with the ddclient docker instance to ensure the subdomain is always pointing towards your home network (see our docker tips tutorial on page 66 of the October 2022 issue for further details).

» For those wishing to use a free DDNS hostname, go to www.no-ip.com and choose your own hostname—for example, nickbw.hopto.org – before clicking Sign Up to register a free account and claim the name [**Image A**]. Once registered, visit my.noip.com/dynamic-dns/duc via your account to download the Dynamic Update Client—this can be installed on any computer on your network, but if you do install the Linux client on your Ubuntu Server-powered PC, we'd recommend installing the beta v3 build—command-line instructions are provided.

» From there, head to www.noip.com/support/knowledgebase/running-linux-duc-v3-0-startup-2/ to discover how to configure the DUC to start with your server and keep your DDNS hostname linked to your home network going forward.

2 SET UP A REVERSE PROXY

Next, you need to configure your server to allow you to use your new DDNS domain to remotely access your password server. We also want to ensure the connection between remote devices and your network is secure, which requires obtaining an SSL certificate for your DDNS hostname. Both requirements can be met using the web-based Nginx Proxy Manager (https://nginxproxymanager.com) docker container.

» Before we install it, we need to create a dedicated bridge network in docker so Nginx and Vaultwarden can communicate with each other. That's achieved with the following command, which creates a bridge network called 'shared-net' (feel free to change the name):

```
docker network create shared-net
```

» Now we're ready to install Nginx Proxy Manager. From your main PC, open a new browser tab and log into your server through cockpit, then switch to the Terminal view. Now open a text editor program such as Notepad and populate a blank document with the following lines:

```
docker run -d \
  --name=nginx-proxy-manager \
  --net=shared-net \
  -p 443:443 \
  -p 80:80 \
  -p 81:81 \
  -v /home/dockeruser/containers/nginx/data:/data \
  -v /home/dockeruser/containers/nginx/letsencrypt:/letsencrypt \
  --restart unless-stopped \
  jc21/nginx-proxy-manager:latest
```

WHAT YOU'LL NEED

The instructions for this tutorial are based on our NAS build from the September 2022 issue. This assumes you'll install your password server on a headless Ubuntu Server-powered PC running docker, accessed through a remote web browser via its web-based cockpit user interface.

You can install docker on other systems, including Windows through the Windows Subsystem for Linux (WSL 2), in which case, you can administer it through the Windows Terminal command line interface using the same commands listed here. To find out more about installing and using docker, check out our top tips on page 66 of the October 2022 issue.

We've chosen Vaultwarden (https://github.com/dani-garcia/vaultwarden) because it's a well-established unofficial fork of Bitwarden that's been optimized for use on low-powered servers—we have entrusted it with our passwords for the past three years. We also recommend you take a secure backup of your configuration files and password database. We recommend Duplicati (www.duplicati.com), which we covered in our security and privacy feature in our January 2023 issue. For maximum security, make sure at least one backup is stored remotely. Duplicati can encrypt all backups to make them safer to store online.

» This creates a new docker instance called 'nginx-proxy-manager' based on the latest available version that is connected to the 'shared-net' bridge network you just created. It manages connections through the standard http (80) and https (443) ports, and you'll connect to its web-based interface through port 81. It also maps two folders to directories on your hard drive where your Lets Encrypt SSL certificate and proxy data are stored.

» You'll need to adapt the two lines beginning '-v' to point towards wherever it is you're storing your container data. Save the text file somewhere safe on your PC's main hard drive before pressing Ctrl + A followed by Ctrl + C to copy the script to the clipboard. Now switch to cockpit's Terminal and press Shift + Insert to paste the code in. Press Enter, and if all is well, Nginx Proxy Manager will now be running.

» Should you ever need to recreate Nginx Proxy Manager in the future, simply reopen this text file, then copy and paste its contents into the Terminal as before.

3 CONFIGURE NGINX PROXY MANAGER
Access Nginx in a separate browser tab via http://192.168.x.y:81 where 192.168.x.y is your server's IP address. Log in with admin@example.com (email) and changeme (password) before adding new login details when prompted.

» Before moving on, you need to log into your router's configuration utility and redirect ports 80 and 443 to the same ports on your server via its port-forwarding tools. Make sure the destination device is your server's network IP address (192.168.x.y) before clicking Apply.

» Once done, return to Nginx Proxy Manager to obtain a free SSL certificate for your DDNS hostname. Click SSL Certificates followed by 'Add SSL Certificate'. Enter your DDNS hostname into the 'Domain Names' box and click add when it pops up. Make sure the same email address you use for your No-IP account is entered, flick the switch agreeing to the T&Cs, and click Save [**Image B**]. After a minute or so the certificate should be added.

4 INSTALL VAULTWARDEN
With Nginx and your domain set up and ready to go, it's finally time to install your new password manager. Create a new text document and input the following lines:

```
docker run -d \
  --name vaultwarden \
  --net=shared-net \
-v /home/dockeruser/containers/bitwarden:/data/ \
-e SIGNUPS_ALLOWED=true \
-p 4000:80 \
  --restart unless-stopped \
vaultwarden/server:latest
```

» Once done, modify the '-v' variable to point to your chosen storage folder and save the file. Select all the text and press Ctrl + C. Now switch back to cockpit's Terminal view and press Shift +
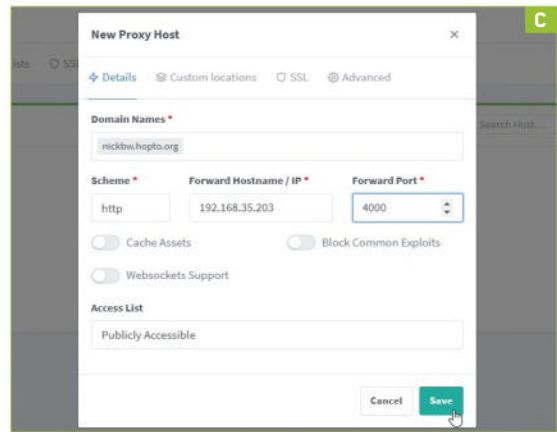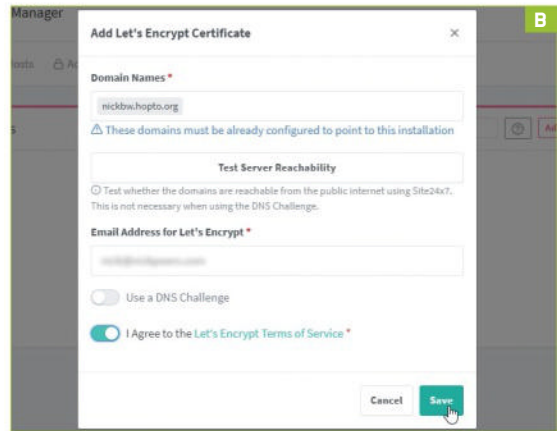
Insert to paste the command into the Terminal, then hit Enter. Once VaultWarden is up and running, open a new browser tab and go to http://192.168.x.y:4000 (again, substitute x.y with your server's IP address).

» You should see the VaultWarden login screen. You'll notice that the connection is insecure, but don't worry—it's only accessible through your own local network and Vaultwarden won't actually let you login through this connection because it's not secure.

» It's time to finally match up Vaultwarden with Nginx and your DDNS domain. Return to Nginx's dashboard and click Proxy Hosts followed by Add Proxy Host. Enter your DDNS hostname into the Domain Names field, leave http selected as the 'Scheme', enter your server's IP address into the 'Forward Hostname/IP' field and change the Forward Port to 4000 [**Image C**].

» To ensure your connection is secure, switch to the SSL tab and click inside the SSL Certificate box. You should see your previously created SSL certificate is listed as an option—select this, then flick the 'Force SSL' switch on before clicking Save.

» You're now ready to test your connection. Open a new browser tab, type in your DDNS hostname, and hit Enter. You should find yourself at the VaultWarden login screen via a secure connection (click the padlock next to the URL to verify the connection is seen as secure).

5 COMPLETE BASIC SETUP
We're just about done with all the 'technical' stuff, so let's get your password account set up. Simply click 'Create account', then fill in the required fields:

© WWW.NO-IP.COM, NGINXPROXYMANAGER.COM
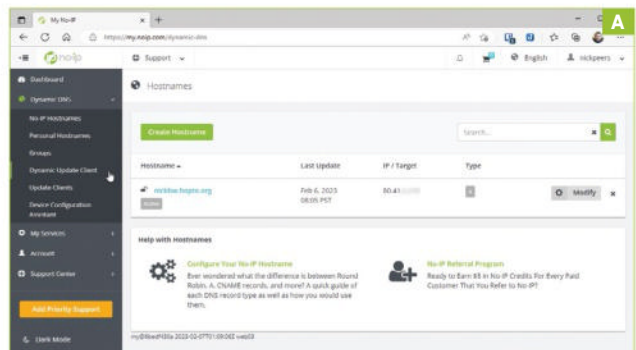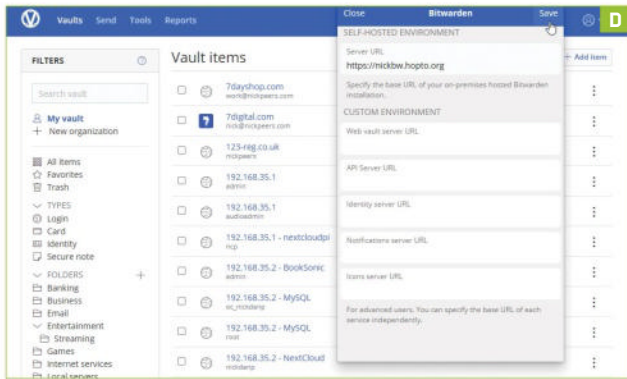
email address, name, and master password. This is the only password you'll need to remember going forward, so make it long and not easily guessable. Use a passphrase containing three unrelated words, such as aardvark-submarine-macgyver—choose words that aren't linked but will stick in your head.

» While you can leave yourself a master password hint, remember your server is accessible to anyone who types your DDNS hostname into their browser, so while this is extremely unlikely to happen by accident, it still pays to keep it cryptic.

» Once that's done, click 'Create account' again and you'll be taken back to the login screen with your email address pre-filled. Click Continue, enter your master password, and click
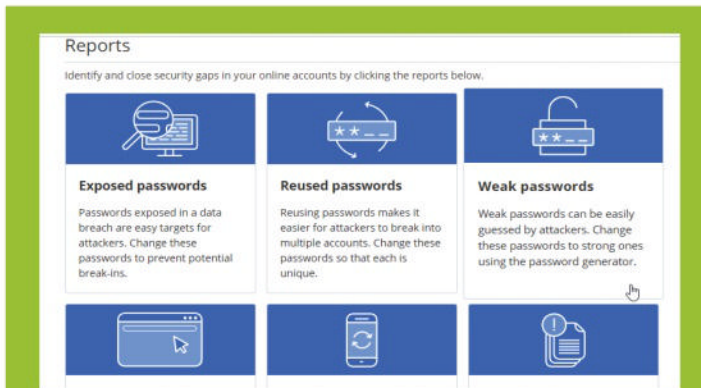
RUN A PASSWORD AUDIT

Your Vaultwarden server gives you access to all of Bitwarden's features, including its range of password-auditing reports. These enable you to discover which passwords are weak, re-used, or involved in known breaches. Follow the prompts via the Reports menu and a list of logins that fail the audit will be displayed.

Updating passwords is time-consuming, but we recommend using the Bitwarden browser plugin. Leave the main web vault open in its own tab, then work through the list one by one: log into the relevant website using your existing credentials, then navigate to the account section and look for the option to change your password. Use Bitwarden's password generator (use a minimum of 14 characters and a mix of letters, numbers, and symbols) to create a strong, randomly generated password in its place.

Once the password is generated and copied to the clipboard, immediately log out of the account and log back in, this time pasting in your newly generated password. Bitwarden should detect the password has changed and offer to update your vault. If it doesn't do this, edit the item manually, either in the browser plugin window or through your web vault.

'Log in with master password' to find yourself at the main Bitwarden web vault.

6 TIGHTEN SECURITY FURTHER
Before going further, let's add another layer of security to your account so that even if your password is compromised, bad actors can't get at your passwords. Click the account icon in the top right corner and choose 'Account settings'. Select Security from the left-hand menu, then switch to the 'Two-step login' tab.

» You'll see a range of 2FA options available, from simple email verification codes to physical security keys. If you use an app like Authy to generate and manage codes, click Manage next to 'Authenticator app' and follow the prompts. Once set up, click 'View recovery code', enter your master password, and make a note of the code, which you'll be able to use to recover your account should you lose access to your 2FA key or app.

» Test everything's working by clicking the account icon and choosing 'Log out', then log back in with your master password and 2FA key.

7 IMPORT PASSWORDS FROM OTHER ACCOUNTS
If you're switching from another password manager, including the cloud-hosted version of Bitwarden, your next task is to transfer your passwords.

» Select Tools followed by 'Import data', then click the 'Select the format of the import file' to see what formats Bitwarden supports (it's a huge number). If your password manager is listed, select the format from this list. Bitwarden will helpfully display a link to a web page providing instructions for what to do next, but in most cases, you'll simply use your existing password manager's export tools to create a compatible file containing your passwords. Once done, click 'Choose File' and finally click 'Import data'.

» If the data import is successful, you'll be returned to the main vault screen with your usernames, passwords, and other compatible data (such as credit card information and secure notes) intact. The instructions provided by Bitwarden should give you a good idea of what's imported and what isn't. Don't forget to destroy the password file before proceeding. Use a tool like File Shredder (www.fileshredder.org) to leave no traces of the file (and your passwords) on your hard drive.

8 SET UP CLIENT ACCESS
Your Vaultwarden server is accessible from any Bitwarden app or browser plugin, which are freely available. If you're struggling to track them down, click the account button on your web vault and choose 'Get the apps' or visit https://bitwarden.com/download/.

© VAULTWARDEN
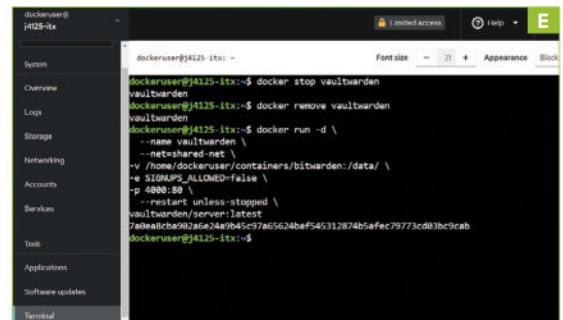
ANATOMY OF YOUR STORED LOGONS
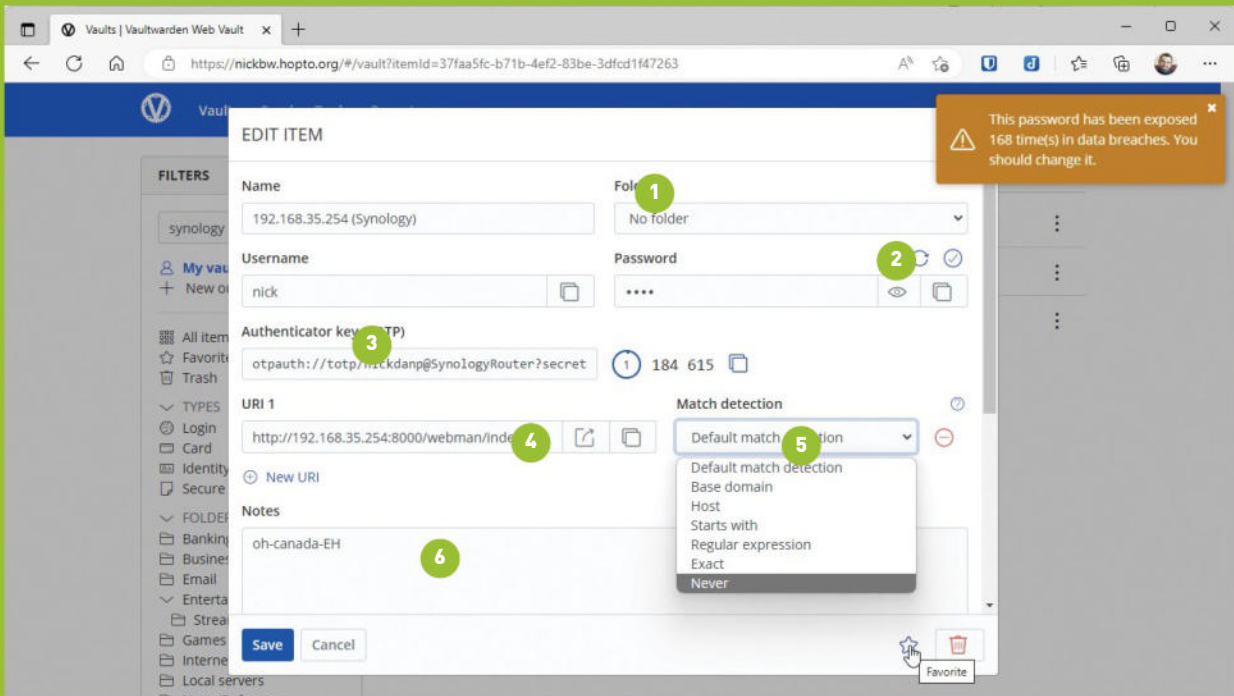
1. FOLDER
As your collection of logons grows, take the time to organize them into folders and subfolders. You can manage these via the main web vault screen.

2. PASSWORD
View or copy the password from here—you can also generate a new password or check to see if the password has been breached using the blue buttons.

3. AUTHENTICATOR KEY (TOTP)
Bitwarden can also be used to store 2FA authentication codes—simply add the key displayed beneath the QR code into this field when setting up 2FA.

4. URIs
These link logon items to websites or domains. You can link a single logon to multiple URIs. Click the '+ New URI' button to add more.

5. MATCH DETECTION
In most cases, Bitwarden's default match detection ensures the logon is offered when you browse anywhere within a web domain, but you can set fuzzier matches, including base domains and regular expressions.

6. MORE FIELDS
You can also attach notes or create custom text fields—useful for additional sensitive information. Click the star button to add the logon to your list of favorites.

» When you log into the app, you'll need to instruct it to connect to your own server rather than the main Bitwarden cloud server. This is done by clicking the settings button on the main login screen. Simply enter your DDNS hostname as shown in [**Image D**] and click Save, then log in as normal. The apps and plugins work in the same way as they do with the main Bitwarden server—see the annotation for details of what's stored, and visit https://bitwarden.com/help/ for a series of comprehensive how-to guides. Remember, Vaultwarden provides almost the exact same functionality as Bitwarden itself.

9 BLOCK OTHER USERS
One final step: as things stand, anyone who knows (or stumbles upon) your DDNS hostname can set up their own password account on your server. To prevent this, create accounts for everyone who needs them right now, then destroy and recreate the Vaultwarden container with a configuration tweak that blocks the creation of new accounts (remember, this doesn't affect your configuration files or password database).

» To do this, switch back to cockpit's Terminal view and issue the following commands:

```
docker stop vaultwarden
docker remove vaultwarden
```

» This destroys the VaultWarden container (but not your configuration data or passwords). Now simply open the text file containing your previous VaultWarden setup command, but make one change to the SIGNUPS_ALLOWED line so it now reads:

```
-e SIGNUPS_ALLOWED=false \
```

» Select all the text again, copy and paste this back into the Terminal window as before and hit Enter to recreate Vaultwarden [**Image E**]. Return to the browser window and click 'Create account' again. While you can fill in the form as before, clicking 'Create account' at the end of it will throw up an error telling you that new accounts can't be created. Should you ever need to give someone an account on your server in the future, just repeat the above step, substituting 'false' for 'true', create the new account, then revert to the 'false' setting again.

» Congratulations! Your self-hosted Bitwarden-based password server is up and running, ready to securely store your passwords going forward. ⏻

Check for lost data packets on your Wi-Fi

WHEN DATA IS SENT across the internet, it rarely travels in one big chunk. Instead, every email, photo, or streamed song is chopped into smaller pieces called packets, which bounce from one server to the next until they reach your PC. There's no guarantee they will all take the same route, nor that they arrive in the right order. Therefore, each packet carries additional data, a bit like the address on an envelope, that makes clear which other packets it goes with, and where it fits in the overall collection. Your computer uses this data to reconstruct the original file or stream, before sending it on to the email client, photo viewer, or audio player that requested it.

For the most part, it works, and pictures and messages routinely arrive uncorrupted but every so often, packets get lost along the way or may miss their slot. That's not really a problem with emails, which can wait a few milliseconds to give the missing data a chance to catch up, but streaming is inherently time-sensitive, so packet loss is more obvious. If your video-calling software has to wait for delayed packets, you may notice the stream freezing and, if they never arrive or miss their slot entirely, you might see glitches and momentary blackouts. In the worst case, the software may give up entirely and cut the call. Packet loss can happen anywhere on the data's journey and, if you're regularly suffering from this, you should diagnose where the problem is occurring and, if it's your own network, do something about it. **–NIK RAWLINSON**

1 CHECK THE CONNECTION TO YOUR ROUTER
If your problems occur when you're using a computer that's connected physically to your network using an Ethernet cable, leave it where it is. But if you have a wireless connection, make sure your computer is in the position where it normally suffers packet loss before you start running any tests.

» If your computer is fine but you're having trouble streaming to your TV using a streaming stick, try to replicate the device's operating conditions. The simplest way to do this, if you have a laptop, is to move it as close as you can to where the streaming device is located. That way, although your laptop's internal wireless hardware will be different from that of the streaming device, it will at least experience a signal of similar strength.

» If your streaming device has a physical connection, and you have an Ethernet port on your laptop, disconnect the device, and use the same cable to connect your laptop, then turn off the laptop's wireless connection. You can do this by clicking the wireless icon on the Windows taskbar. In Windows 10, click the Wi-Fi button on the panel that appears, or in Windows 11, click the left half of the split Wi-Fi button at the top of the panel. Now that you've set up your testing environment, you can begin.

2 RUN THE 'PING' TEST IN COMMAND PROMPT
You're going to use the ping command, which works like sonar in a submarine. Sonar stands for Sound Navigation and Ranging, which explains exactly what it does: a simple implementation sees a submarine send out a 'ping' sound and listen for an echo. If the echo takes a long time to arrive, it indicates that the way ahead is clear. If it comes back almost immediately, it suggests there is an obstruction.

» Here, you'll ping your router and various servers on the internet by sending them a packet of dummy data and timing how long it takes for it to be bounced back. The difference between ping and sonar is that, while a long delay is good news in sonar, it's bad news when pinging, because it indicates an obstruction on the path between your PC and the router or server.

» As well as measuring how long a data packet takes to complete its journey, the ping function will tell you whether any data was lost en route, which is potentially even more serious than it simply being delayed.

» It makes sense to start close to home. If the problem is inside your house, you can immediately work on a remedy without any further testing. The first thing to do, then, is to ping your router. To do that, you need to know where your router is on your network.

» Open the Start menu, type cmd and click Command Prompt. When the prompt appears, type ipconfig /all and press Enter. Look for the four sets of digits to the right of Default Gateway in the result. This is the numeric address of your router on your local network.

» On our network, we have two routers. The one that connects directly to our broadband connection is located at 192.168.1.254. Another, which acts as a gateway between the router and the devices on our network (so it can provide a Wi-Fi 6 signal, which our broadband router doesn't support) is at 10.0.0.1. Both of these are common addresses for routers but yours may be different.

» We'll test both connections eventually, but we will start with the connection to the broadband router at 192.168.1.254. Type the following and replace that address in the code below with the address of your broadband router: ping 192.168.1.254.

» Press Enter and your PC will send four packets of data to your router, and report how long they take to come back or, if they don't come back at all, how many packets were lost.

» As the data never passes beyond your local network, it should ideally complete its trip quite quickly. You want to be seeing an average round-trip time of 20 milliseconds or less (unless there's an online gamer in your household, in which case, they'll want something around 10 milliseconds or better—not only to your router but to any gaming server they connect to on the internet).

» However, for our purposes, unless your response times are incredibly slow, what's far more interesting is packet loss. If you're routinely seeing a lot of packets

```
(c) Microsoft Corporation. All rights reserved.

C:\Users\nik>ping 192.168.1.254

Pinging 192.168.1.254 with 32 bytes of data:
Reply from 192.168.1.254: bytes=32 time=4ms TTL=64
Reply from 192.168.1.254: bytes=32 time=8ms TTL=64
Reply from 192.168.1.254: bytes=32 time=7ms TTL=64
Reply from 192.168.1.254: bytes=32 time=7ms TTL=64

Ping statistics for 192.168.1.254:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 4ms, Maximum = 8ms, Average = 6ms

C:\Users\nik>
```

going astray, it's cause for alarm. We got some good results—with four packets sent and received [**Image A**] and an average round-trip time of six milliseconds.

3 INCREASE THE PING TIME

The ping command is quite versatile and has several options that let you tailor how it works. If you want to perform a more thorough test, for instance, you can increase the number of data packets it sends and listens for with the -n command. And, if you're seeing a lot of lost packets, you can increase the amount of time a ping waits for them to appear before considering them AWOL using the -w command. By default, it waits 4,000 milliseconds (four seconds), but on a really problematic connection, even this might not be enough.

» For example, the following ping -n 10 -w 8000 192.168.1.254 increases the number of packets sent to 10 and doubles the waiting time (or timeout time as it's officially called) by setting it to 8,000 milliseconds (eight seconds).

» Whatever results you get on your first few tests, write them down (or, better still, record them in a spreadsheet), then repeat the test at different times of the day over the next few days, as the result can be affected by external factors, such as congestion on your wireless network or interference from a nearby network.

4 CHECK WHETHER YOU NEED A WI-FI EXTENDER

If you notice that ping performance is good all day but gets slow and starts dropping packets when your neighbors arrive home, it's likely the problem is a local one and has nothing to do with your own broadband connection.

» If this does seem to be the problem, the most effective fix is often to tweak your wireless network, which needn't cost a fortune. Try moving your router to a more central location (though this won't be possible if it needs to stay connected to the socket through which broadband enters your home).

» If you can access your router's configuration pages through a browser, usually by typing its numeric address and then the password on the back of the case, try changing the Wi-Fi channel it uses. The one it's currently set to may be the same as your neighbor's, resulting in wireless congestion and slower speeds.

» Should none of these remedies work, the solution may be a wireless range extender, such as TP-Link's RE700X.

» If you want to make sure this is the best option before spending any money, move your computer next to the router and repeat the tests. If the problem disappears, it suggests the network signal is having trouble traveling through your home and being degraded as it encounters obstacles such as walls.

» If you're using a physical, wired connection to your router, wireless network congestion won't be the problem. Instead,

the other devices on your network might be using more than their fair share of the available bandwidth, slowing down your connection so much that ping considers the packets lost.

» Try repeating the test with as many other devices as possible, either disconnected or turned off to see if it makes a difference. If it doesn't, check your computer for malware and, if possible, replace the connection, as a damaged Ethernet cable could also result in lost data.

» If you're connecting to the router via Powerline networking kit, and you're able to connect directly, try that: if the wiring in your house is old, perhaps the data is being degraded along the way.

5 PING WEBSITES TO CHECK YOUR BROADBAND CONNECTION

If there's no problem with the data passing between your computer and your router, you need to see whether the problem lies with your broadband connection. Type ping www.google.com into Command Prompt [**Image B**], then press Enter.

» As you may have worked out, this repeats the tests you ran on your router but sends the data packets to Google instead. Make a note of the results, and repeat the test several times over the course of a few days. Vary the test server, too, so you can rule out problems with a particular route between your computer, your ISP, and the destination. For example, try typing:

```
ping www.microsoft.com
ping www.cnn.com
```

» Notice that we've focused on major websites here, because they are most likely to be optimized for performance and quick responses, so should deliver among the shortest response times while minimizing lost packets.

» We generally achieved excellent results but did lose one packet when pinging CNN's website, as you can see in our screenshot below.

» If you're experiencing a lot of lost data to a wide range of sites, it suggests a problem with your broadband connection. This could be caused by the physical connection on the other side of your router, the cable to the local street cabinet, wiring inside the cabinet itself, or another issue beyond your control. In each case, it's a problem you need to raise with your ISP because the remedy is unlikely to be something you can carry out at home.

» It may help your ISP if you offered to share the results of your ping tests between both your PC and your router, and your PC and websites. ⏻

```
Microsoft Windows [Version 10.0.19045.2251]
(c) Microsoft Corporation. All rights reserved.

C:\Users\dbooth>ping www.google.com

Pinging www.google.com [2a00:1450:4009:819::2004] with 32
Reply from 2a00:1450:4009:819::2004: time=34ms
Reply from 2a00:1450:4009:819::2004: time=18ms
Reply from 2a00:1450:4009:819::2004: time=18ms
Reply from 2a00:1450:4009:819::2004: time=18ms

Ping statistics for 2a00:1450:4009:819::2004:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 18ms, Maximum = 34ms, Average = 22ms

C:\Users\dbooth>
```

Back up your PC for free

AS WE'VE MENTIONED before, the excellent Macrium Reflect Free is being retired, taking with it one of our favorite (and free) ways of backing up. Thankfully, there is an excellent alternative in the form of Hasleo Backup Suite 3. It's a powerful yet easy-to-use backup tool with all the essential features most people, even power users, will need.

In this tutorial, we'll show you how to use Hasleo Backup Suite 3 to back up both individual files and your entire Windows installation. The only other thing you'll need is an external hard drive or SSD, but you can buy the Seagate Portable 2TB 2.5-inch hard drive for $70, or a Toshiba 4TB Canvio model for $165. Whatever your storage needs, it's a small price to pay for long-term peace of mind in case the worst happens, which it sadly does fairly often. –**GUY COCKER**

1 DOWNLOAD HASLEO BACKUP SUITE 3
First of all, download Hasleo Backup Suite 3 (tinyurl.com/ytj4zm6b). When that's been completed, navigate to your Downloads folder and launch the file.

» Microsoft Defender showed a SmartScreen alert telling us that the software was from an unknown publisher and that to protect our PC it had blocked it from running. This is a false positive result, so If you see the same message, click 'More info', followed by 'Run anyway'. Select the language you want to use, then follow the instructions to install the suite.

2 LAUNCH BACKUP SUITE
Start the program, and it will ask you if you want to set the default storage folder for your backup image files. You should never store your backups on the same drive as the original data—if it corrupts, you risk losing both the original files and your copies—so attach an external drive to your computer and click Yes [**Image A**].

» Click the folder icon in the box that appears, then navigate to the drive you connected, and click Select Folder. Click OK to complete the process. You're ready to make your first backup.

3 START BACKUP
Click 'New Backup' and you'll see three options: System Backup, which backs up everything; Disk/Partition Backup, which lets you select any item that appears as a disk in Windows' File Explorer; and File Backup, which lets you back up individual files and folders.

» Select 'File Backup' [**Image B**], then click the checkboxes beside the files and folders you want to back up (see Step 5). When you select a folder in the left-hand pane, its contents are shown and can be selected in the right-hand pane.

4 PROTECT YOURSELF
When you've created a backup, you can restore it easily using another copy of Backup Suite. That way, if your PC is irreparably damaged, you won't lose your files. However, it also means that anyone who comes across your drive can download Backup Suite and obtain a complete copy of your data.

» To prevent this, click 'Backup options', then Encryption [**Image C**] in the sidebar, and tick the box beside 'Enable encryption'. Type a password into both boxes and click the option to 'Use 256-bit encryption', followed by OK to password-protect your backup. Now you'll need to enter the password before you can recover your files, so don't forget it!
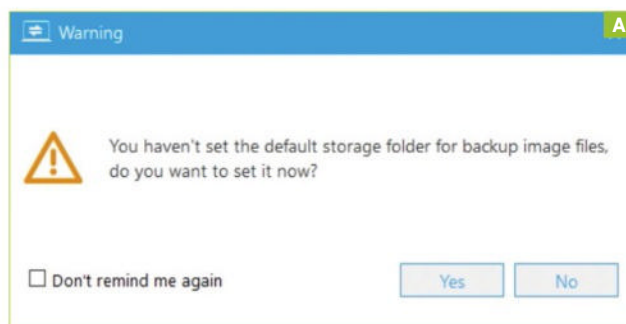
5 BECOME A TASKMASTER
Once you've selected all the files you want to back up, take a look at the 'Task name' [**Image D**] and Description lines below the two panes. This information can help you identify your backup if you need to dig into it to recover a specific file, so change it if necessary.

» Make sure the information accurately describes what you're backing up, then click Proceed. Hasleo Backup Suite will copy your files to the external drive in a format that keeps everything together, with a progress bar indicating how much longer the job will take.

6 BE RESTORATION READY
Should you ever need to restore your files, click Restore [**Image E**] in the sidebar, followed by 'Browse image to restore'. Navigate to the backup

C

Backup options

- Space
- Encryption
- Command
- Notification
- Advanced

☑ Enable encryption

Enter password ●●●●●●

Confirm password ●●●●●●

☑ Use 256-bit encryption

D

Hasleo Backup Suite Free

File Backup

Home | Backup | Restore | Clone | Tools

☐ Desktop
  ☐ from hp
  ☐ Old Firefox Data
  ☐ scrivener how-to
  ☐ Tidy
☑ Documents
☐ My computer
☐ Network

Name	Date modified	Size
Custom Office Templates	06/06/2022 11:44 AM	
Downloads	03/23/2022 05:55 PM	
Freelance	12/01/2022 03:11 PM	
old	12/07/2022 01:47 PM	
Outlook Files	02/28/2022 06:01 PM	
Processing	12/10/2022 05:03 PM	
quizzes	03/01/2022 03:56 PM	
sarnia dashboard	12/14/2019 07:33 PM	
software downloads	03/01/2022 03:55 PM	
Sound Recordings	09/01/2022 03:44 PM	
the letters	01/02/2022 09:29 AM	
travel	03/01/2022 03:55 PM	
typewriter art	03/01/2022 03:56 PM	
websites	12/07/2022 01:33 PM	

Task name: File Backup 20221222153926   Description: File Backup at Thu Dec 22 15:39:26 2022

Destination: D:\

Backup options   Backup schedule: None

Back   Proceed

E

Backup Suite Free

Select what you want to restore

File Backup 20221222153926
12/22/2022 04:49:48 PM Full   Version history

☐ Custom Office Templates
☐ Downloads
☑ Freelance
  ☑ Computer active
    ☑ batch files
  ☐ Computer Shopper
  ☐ Expert Reviews
  ☐ idg
  ☐ Ovingo
  ☐ Padua
  ☐ PC Pro

Name	Date modified	Size
☑ backup-stuff.bat	08/30/2022 10:35 AM	1 KB
☐ shutdown.bat	08/30/2022 10:35 AM	1 KB

○ Restore to original location

● Restore to:

☑ Replace existing files ☑ Restore NTFS permissions

Back   Proceed

containing your missing files (at this point, you'll understand why we suggested using an accurate description for the backup), and click Open. Use the checkboxes in the two panes to select the files and folders you want to restore.

» If you want to overwrite the current versions of your files, click 'Restore to original location'. Otherwise, click 'Restore to',

followed by the folder icon, then navigate to the folder to which you want to restore the backed-up files. Click 'Proceed' to recover the data.

7 SCHEDULE AWAY

The latest version of Hasleo Backup Suite includes an improved scheduler to help ensure your backups are always up to date. To create regular backups of your entire boot drive, including Windows, click Backup, then Disk/Partition Backup, and select drive C [**Image F**]. Click 'Backup schedule' and select an interval from the box that appears. We'd suggest Weekly.

» Click to select which day of the week the backup should take place and, if you wish, select a time, then click OK. Click Save and your backup will begin at the chosen date and time. ⏻

F

Hasleo Backup Suite Free

Disk/Partition Backup

Home | Backup | Restore | Clone | Tools

☑ Disk 0 (Basic, GPT, 476.94 GB)

*: SYSTEM (FAT32) ☐
228.23 MB free of 260.00 MB

*: (Other) ☐
0.00 MB free of 16.00 MB

C: OS (NTFS) ☑
294.05 GB free of 475.89 GB

*: RECOVERY (NTFS) ☐
205.48 MB free of 800.00 MB

☐ Disk 1 (Basic, MBR, 447.13 GB)

D: Backup (NTFS) ☐
446.70 GB free of 447.13 GB

Task name: Disk Partition Backup 20221222172151   Description: Disk/Partition Backup at Thu De[c]

Destination: D:\

Backup options   Backup schedule: Weekly

Back

Backup schedule

Schedule type:
○ None
○ One-time
○ Daily
● Weekly
○ Monthly
○ Event trigger

Run once at 05:22 PM

Sun | Mon | Tue | Wed | Thu | Fri | Sat

Set the default backup mode as: Incremental ▼

☐ Wake up the computer to execute the schedule

☐ Run missed schedule at the next system startup

Cancel   OK

Switch to private versions of software

WANT THE BENEFITS of your favorite programs without them collecting your data? Well, the good news is you can, by using 'forked' versions. The code for open-source software is made freely available to other developers, so they can help improve programs by identifying bugs and suggesting new features. This collaboration often involves 'forking', which allows you to modify somebody else's project, share the changes you've made and let the original developer decide whether to incorporate your modifications. But some 'forks' result in software being turned into a completely new project because users are unhappy with the direction the original developer has taken. Privacy concerns are among the most common reasons for forking, which has resulted in some interesting open-source alternatives. Here we reveal the best private forks of popular tools, and how to use them. –ROBERT IRVINE

1 SWITCH TO A GOOGLE-FREE CHROMIUM BROWSER

If you want to stay private when browsing the web, Chrome is far from ideal. Even if you don't use the browser's Sync feature, which saves data such as your bookmarks, browsing history, passwords, and contact details to Google's servers, Chrome still shares details of your web activities in the background. This is officially intended to help Google 'improve its services' and the browser's performance, but also means it can see every page you visit and use that information to target you with ads from its partners.

» The best way to avoid this tracking is to switch to a more private browser, such as Brave (www.brave.com) or Vivaldi (www.vivaldi.com). However, because these tweak Google's Chromium code to use custom interfaces and add their own features, you may find them confusing to use, Vivaldi in particular.

» To keep the simplicity of Chrome but lose the invasion of your privacy, you may feel more comfortable with Iridium Browser (www.iridiumbrowser.de). This Chromium 'fork' looks like a streamlined version of Chrome and includes that browser's main tools, but removes nearly all traces of Google.

» The default search engine is the privacy-focused Qwant (www.qwant.com)—you can change this to DuckDuckGo if you prefer—and all Google's data-sharing features are disabled. This means you can't sign into Google or sync your data across devices, though the browser does use Google Safe Browsing to protect you from dangerous sites. Third-party cookies are blocked by default and you can install extensions from the Chrome Web Store if you want to use your favorite privacy add-ons such as uBlock Origin and Privacy Badger.

» The main drawback to using Iridium is that it doesn't update automatically because "it would need to call home [to Google], which is blocked for maximum privacy". Therefore, you'll need to visit its website periodically to download the latest version [**Image A**].

2 USE A MORE PRIVATE VERSION OF FIREFOX

Mozilla has recently made improvements to Firefox's privacy settings, including Enhanced Tracking Protection, which automatically blocks third-party trackers from collecting and selling your web activity. However, in other ways, the browser isn't private enough because Mozilla itself uses telemetry to gather data about you, including your IP address, to improve performance and stability, recommend extensions, and "allow Firefox to install and run studies". It has also started displaying 'sponsored shortcuts' (adverts) in the browser's address bar and on its New Tab page, as well as suggested stories from Pocket.

» Most of these options can be disabled, but the fact they're enabled in the first place has led privacy-conscious users to switch to a fork. The best one is LibreWolf (www.librewolf.net), which is described as "a custom version of Firefox, focused on privacy, security and freedom", and has no affiliation with Mozilla.

» Unlike other forks of Firefox such as Pale Moon and Tor Browser, LibreWolf's interface closely resembles the original, with the same menus and options, but
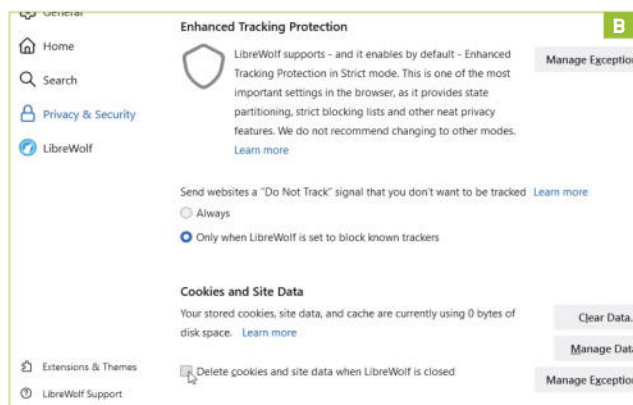
without the ads and distractions Mozilla has added, while all telemetry options are absent from its settings.

» Rather than use privacy-invading Google, the default search engine is DuckDuckGo, and the excellent uBlock Origin extension is pre-installed to block ads, trackers, and other annoyances from the outset. You can install further add-ons from Mozilla's Add-ons site, though LibreWolf's developer recommends keeping these to a minimum to preserve your anonymity.

» The browser includes Firefox's Enhanced Tracking Protection, in case you're worried about losing that useful feature, but sets it to Strict mode to give you the best possible privacy. LibreWolf deletes cookies and site data when you close it, but you can disable this option in the Privacy & Security section of Settings [**Image B**] if you prefer.

» LibreWolf is always based on the latest version of Firefox but, as with Iridium, you'll need to check for updates manually as it won't install them automatically.

3 **DITCH AUDACITY FOR A TRACKER-FREE FORK**
Audacity (www.audacityteam.org) has long been the best and most popular free program for editing audio files. It's packed with useful features for recording, trimming, and enhancing the sound quality of tracks, while its distinctive 'waveform' interface makes it easy to analyze frequencies and experiment with different effects. So why use anything else?

» The problem lies not with the software itself, which is still as powerful and versatile as ever, but with its owner. In April 2021, Audacity was bought by the Muse Group, which owns other audio apps, including *Ultimate Guitar*, *MuseScore*, and *Tonebridge*. Although Muse Group has promised that Audacity will remain free and open-source, changes to the program's privacy policy raised concerns among its millions of loyal users.

» Initially, these changes stated that Audacity would collect users' IP addresses and system information, as well as data that's "necessary for law enforcement, litigation, and authorities' requests", which could be shared with its main office in Russia. Following a huge backlash, the privacy policy was amended
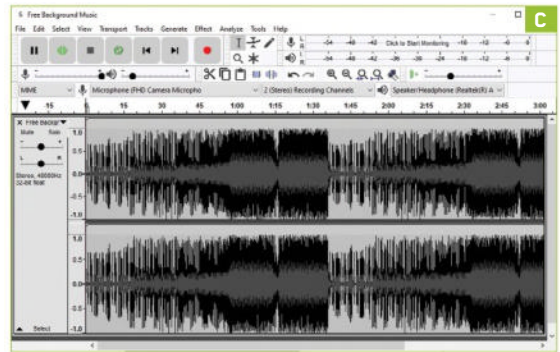
to explain that data is collected anonymously to help identify errors and improve the program. The Muse Group is now based in Cyprus but the damage had been done, with some users even calling it 'spyware'.

» After the takeover, several Audacity forks appeared to provide new versions of the software without any data collection. Two of these, Saucedacity and Tenacity, are being merged and you can download the program from its official website (www.tenacityaudio.org).

» Currently called Saucedacity—it will be renamed Tenacity with the next version (1.3)—it's based on the last version of Audacity before it was bought by Muse Group and looks almost identical. It has all the same features, menus, sliders, and other options and works in the same way. Indeed, the developer suggests you refer to the official Audacity manual (hmanual.audacityteam.org) for how to use it. Some buttons are in different positions and waveforms are black rather than blue [**Image C**], but otherwise, it's the perfect alternative if you're uneasy about Audacity's potential tracking.

» Note that Saucedacity/Tenacity may trigger a Microsoft Defender SmartScreen warning, but it's safe to use so just click 'More info' then 'Run anyway'. ⏻

IS BETTERBIRD BETTER THAN THUNDERBIRD?

As with Firefox, Mozilla's otherwise brilliant email program Thunderbird has telemetry enabled by default. This means it shares 'technical and interaction' data with the company to help improve the software. It's not a major privacy intrusion and can be disabled in Thunderbird's 'Privacy & Security' settings, but if it bothers you there is a forked version called Betterbird (www.betterbird.eu).

Described as "Thunderbird on steroids", this offers extra features including a choice between plain-text or HTML messages, more search filters, and the ability to attach recent files— see the full list at (www.betterbird. eu/#featuretable)—and it disables telemetry by default (see screenshot).

However, with something as sensitive as your emails, using a fork that may not be maintained in the long term could pose a security risk. Currently,

Betterbird follows Thunderbird's release schedule and is updated in line with its latest version (though you need to install updates manually). As

the program is only a 'soft fork', with minimal differences, and doesn't offer additional privacy options, you're better off sticking with the original version.

LAB NOTES

JEREMY LAIRD, JOB TITLE

Samsung on the slide

What is going on with Samsung's quality control?

AS FALLS from grace go, Samsung's has been precipitous of late. For two weeks running, the South Korean tech giant was forced to release firmware updates to fix flaws on its premium SSDs. First, the 980 Pro had to be patched to address an apparent epidemic of spontaneous drive deaths, themselves reportedly caused by an earlier flawed firmware update.

Then the latest 990 Pro model had to be patched following widespread reports of declining drive health as registered by Samsung's own Magician SSD tool. For a brand that a few years ago was the gold standard in solid-state storage, both from a reliability and a performance perspective, this is a pointedly parlous state of affairs.

Samsung SSDs have gone from the default choice to a brave roll of the dice. The damage to the brand is going to take much longer to repair than it took to inflict.

What's going on at Samsung? Along with these flaky SSDs, the company has rolled out a series of buggy mini-LED monitors, including the Neo G9 megamonitor, which was the subject of my mystified musings a few issues ago.

In many ways, the messed up monitors are harder to comprehend than the SSDs, which work fine most of the time. Particularly with the 980 Pro, the failures only began to pop up in certain conditions with a specific firmware applied. It's not hard to imagine how an issue like that can be initially overlooked. But the screens are so obviously flawed, even in casual use, I can't understand how they ever got signed off as fit for customer consumption.
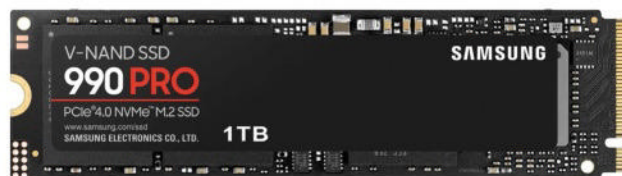
Samsung's 990 Pro SSD is the latest product to face QA issues.

Could it all be symptomatic of a broader corporate malaise? Samsung is a huge, sprawling tech conglomerate. So, it's not as if the SSD guys are working on the desk one over from the monitor team. But with quality control going south on such disparate product lines, you have to start asking questions of the people higher up the chain. Personally, I'd think twice about buying any Samsung product now. I doubt I'm the only one, and if that doesn't worry Samsung deeply, it absolutely should.

SAM LEWIS
Staff Writer

Maintaining eye contact isn't always the easiest thing to do, if anything it's a little awkward and it's made even worse when you know you have to keep eye contact in a professional manner. Many of us struggle with this and it can come across as if you aren't paying attention when in most cases, that isn't true. However, could technology have intervened to save the day once more? Nvidia Broadcast 1.4 brings in what they like to call "Eye Contact", and well, it does exactly that.

Nvidia Eye Contact uses AI technology to move the eyes of the speaker toward the camera giving the illusion that they are maintaining eye contact with the audience. It's a little creepy when you first try it out, and it's still in its beta stage, but from our hands-on, it works pretty well. When you look too far from the camera, it has a smooth transition effect, so you don't have to worry about your eyes jumping all over the place.

So why would you use this? I can think of a few reasons why; if you have a widescreen monitor and you're checking notes, to improve your engagement, and if you want a nap in the middle of your meeting. We're kidding on the last one. Anyway, if you struggle with eye contact, check it out, as it may help!

With AI gradually working its way more into everyday life, let's just hope we get more of the helpful side to this unpredictable force.

Editor's Pick:
RedMagic 8 Pro

High-end phone with PC-like gaming features

IN OUR OCTOBER 2022 issue, we reviewed the RedMagic 7s Pro gaming phone, calling it "great for gaming, OK for everything else". While its 120Hz display, responsive triggers, and Snapdragon 8+ Gen 1 processor made it a gaming beast, it suffered the issues that plague gaming phones, including sub-par camera performance and a buggy interface.

The RedMagic 8 Pro promises improved cameras, better performance thanks to the Snapdragon 8 Gen 2 processor, and even comes at a cheaper price of $649 for the 12GB+256GB version. RedMagic Studio, the company's Samsung DeX-like offering for gamers, also turns this phone into something of a gaming PC when it's plugged into a monitor or TV.

Let's start with the basics. The powerful Snapdragon 8 Gen 2 processor means it's a gaming powerhouse. Even with demanding titles, such as *Genshin Impact* and *Call of Duty Mobile*, we were able to max out frame rates and quality settings without the phone breaking a sweat. That's thanks to a cooling system that includes a vapor chamber and internal fans, although these features prevent wireless charging.

The 6.8-inch FHD AMOLED display also deserves a mention. We'd have preferred QHD resolution, but this display is colorful, fast at 120Hz, and goes up to 1,300 nits for outdoor gaming. It's also unbroken by any holes thanks to the under-screen camera and runs edge-to-edge with small bezels.

Naturally, all this cutting-edge tech is pretty power-hungry, but RedMagic has crammed in a 6,000mAh battery that far surpasses the capacity of a standard smartphone. The Samsung Galaxy S23 Ultra, for example, 'only' comes with a 5,000mAh battery. This gives you true all-day gaming battery, although we'd have also liked faster charging than you get from the 65W brick in the box.

Then there's that price. At $649 for the 12GB+256GB version, this is significantly cheaper than every other phone rocking this new Snapdragon 8 Gen 2 chipset, even the OnePlus 11, which is $699 for a lesser 8GB+128GB configuration. Our review model was the 16GB+512GB Void edition ($799) with a translucent back, but we prefer the matte black cheaper model.

If it sounds too good to be true, it is. The cameras are the biggest compromise, as always on gaming smartphones. The main rear sensor has had an upgrade to a 50MP Samsung GN5 sensor, as seen on the Pixel 7 and Samsung S22 series. This is fine in well-lit environments, but the rear 8MP ultrawide and 2MP macro cameras, and the 16MP selfie camera on the front let things down. If you like taking selfies or making video calls, this phone isn't for you.

There is one particularly good feature of this phone, and that's RedMagic Studio. It's basically the company's gaming take on Samsung DeX, which allows a desktop gaming experience from a phone. Get a USB-C adaptor with USB ports, video out, and charging, and you can play *Call of Duty Mobile* on a television or monitor with an Xbox or PlayStation controller—a setup that gives you such an edge over other players, it should probably be outlawed.

Also, this phone is so powerful, someone can be playing a game while you're using it as your phone—or even playing a second game on it at the same time. More so than cloud gaming, this feels like the death knell for the traditional games console—in five years, we'll all be playing on our phones instead. **–GC**
$649, www.redmagic.gg

Reviewed...

Intel Core i9-13900KS

The fastest and most power-hungry PC chip ever

THIS 24-CORE Intel Core i9-13900KS Special Edition processor carries an eye-watering $699 price tag, but it's also the first PC chip to run at 6GHz without overclocking, extending Intel's lead over AMD's fastest Ryzen 7000 processors. However, with a whopping 250W base power specification, this 13th gen Raptor Lake chip is also now officially the most power-hungry desktop CPU in history—its voracious appetite even peaks at 320W in a new Extreme Power Delivery Profile.

We'll have to wait a little longer to see what AMD does with the latest generation of its 3D V-Cache processors that have traditionally delivered explosive gains in gaming performance, but the Core i9-13900KS is meant to keep Intel's silicon entrenched at the top of the benchmark charts when AMD's new chips do arrive. That might be a tall order, as the 13900KS is built on the same architecture as the 13900K, with a higher speed binning to accommodate 200MHz faster clock rates.

There's another reason performance enthusiasts might covet this new chip—Intel selects its premium-binned 13900K silicon for the 13900KS, so it's guaranteed to be among the best the company has to offer. That will make the chips attractive to overclockers, as paying an extra $110 improves your odds in the silicon lottery, ensuring you get a cherry chip.

The 13900KS is the fastest Intel desktop PC chip, and even at stock settings, it drew up to 328W and ran at 100°C to scrape out every last bit of performance. Because the 13900KS is a Special Edition, the company will only produce a limited number of these processors. Despite the price, Intel has actually lowered the ceiling for access to its most premium silicon. The previous-gen 12900KS cost $739, but Intel later increased the pricing of all its 12th-Gen chips, bringing it to $823 today.

The difference between the 13900K and KS is that the latter's performance cores have a 3GHz base clock and reach up to 6GHz on two cores via Thermal Velocity Boost (TVB) tech. This allows the processor to shift into higher frequencies if it remains under a certain temperature threshold (70°C for desktop chips). Meanwhile, the standard Turbo Boost 3.0 clock rates reach 5.8GHz. We found that the chip easily peaks at 6GHz, though the impact on workloads can vary.

The KS only holds a slim 1.5 percent advantage over the standard 13900K in our 1080p gaming tests. That delta shrinks to a mere 0.5 percent for 1440p gaming, meaning it is essentially in the noise of the benchmarks. That certainly isn't worth paying the extra for. We see a similar trend in multi-threaded workloads—the KS model offers a one percent improvement over the standard 13900K and essentially ties the Ryzen 9 7950X. The same applies to multi-threaded operations, with the KS just two percent faster than the standard 13900K.

The KS model also has its own new Extreme Power Profile that allows for a 320W power ceiling. Your motherboard will need to deliver the peak current to unleash the full power of the KS, as not all can for long periods. Motherboard vendors allow this feature in the BIOS, but that doesn't mean the motherboard can actually deliver that amount of current.

With a 6GHz peak turbo clock, the i9-13900KS is the fastest-ever gaming chip. But except for extreme overclockers, collectors, and those looking to build the ultimate system, the chip's relatively small performance advantage over the 13900K isn't worth paying $110 extra.

Either way, potential buyers should try and be patient to see how AMD's Ryzen 7000X3D chips perform. They'll come with the 3D V-Cache tech that provided explosive gaming performance gains for Zen 3, and it's possible that it could push Zen 4 into a solid lead in gaming over Raptor Lake. Pricing remains the wildcard, but we expect the high-end 16-core Ryzen 9 7950X3D to land in the same range as the 13900KS. It'll be exciting to see how it all plays out. –PAUL ALCORN

VERDICT

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Intel Core i9-13900KS

➕ **OVERCLOCKED** Record-setting 6GHz Turbo; leading gaming and single-thread performance; strong multi-thread performance; premium binned silicon; overclocking.

➖ **UNDERCOOKED** Price; power consumption; minimal gains over the standard model; requires pricey accommodations.

$699, www.intel.com

RAM BENCHMARKS

	AMD Ryzen 9 7950X	Intel Core i9-13900K	Intel Core i9-13900KS
Cinebench R23 Single Core	2,068	**2,278**	2,276
Cinebench R23 Multi Core	38,385	39,756	**39,954**
CPU-Z Single Core	774	896	**911**
CPU-Z Multi Core	15,716	16,586	**16,723**
Geekbench 5 Single Thread	2,288	2,170	**2,250**
Geekbench 5 Multi Thread	22,857	24,955	**25,557**
Cyberpunk 2077 1080p Ultra (fps)	196	215	**217**
Hitman 3 1080p Ultra (fps)	178	**208**	208
Flight Simulator 1080p Ultra (fps)	**171**	134	140

Best scores in bold. Intel test system consisted of a MSI MPG Z790 Carbon WiFi motherboard, G.Skill Trident Z5 RGB DDR5-6800 RAM. AMD system consisted of a ASRock X670E Taichi motherboard and G.Skill Trident Z5 Neo DDR5-6000 RAM. Both systems used a 2TB Sabrent Rocket 4 Plus and Windows 11 Pro. Gaming GPU was an Asus RTX 4090 ROG Strix OC.

SPECIFICATIONS

Socket	LGA1700
Cores/Threads (P+E)	24/32 (8+16)
P-Core Base/Boost (GHz)	3.0/6.0
E-Core Base/Boost (GHz)	2.2/4.3
Cache (L2/L3)	68MB (32+36)
TDP/PBP/MTP	150W/253W/320W
Memory	DDR4-3200/DDR5-5600
Graphics	Intel UHD Graphics 770
Production node	10nm (Intel 7)

It's the fastest gaming chip ever made, but still not worth the premium over the vanilla 13900K.

ASRock Arc A770 8GB Phantom Gaming D

Phantom card doesn't stand a ghost of a chance

SOMEONE ONCE had an idea that sounded good, but while the circumstances changed, the idea remained. An Arc A770 8GB might have made sense back in 2021, giving people the choice between a $600 16GB and a $500 card with half the memory—those were early estimated prices at the time when Intel was running a contest with Arc GPUs as the prizes. But with the cards only seeing the light of day at the end of 2022 and with significant price cuts since, there's little reason to opt for the A770 8GB over the A770 16GB.

Granted, there's not a massive difference in performance between the 8GB and 16GB A770 cards in our benchmarks, at least not most of the time. They're tied or close enough to it in a lot of games. But then you come to *Forza Horizon 5*, which surpasses 8GB of VRAM use even at 1080p, and performance takes a big hit. That's likely to happen in more games with *Spider-Man: Miles Morales* being another prime example. At 1440p, the 16GB A770 doubles the performance of the 8GB variant.

It's the same problem we've discussed before with Intel Arc GPUs. They're decent, but they arrived almost a year later than Intel probably intended. You almost feel sorry for ASRock, which likely agreed to make the A770 8GB back when it made more sense. If you want an 8GB Arc graphics card, you should instead buy the Arc A750, which is now priced at $250. It's only five percent slower than the A770 8GB on average, and both are equally weak in the same games. If you want to save money, it's the better option.

But there are other choices too. While you can certainly make the argument that the Arc A770 competes well against the RTX 3060, AMD's RX 6700 non-XT card is another story. It's slower in most ray-tracing games (*Minecraft* being an exception, as Intel still has some driver issues in that game), but the RX 6700 often wins by a sizeable margin in rasterization games. It also costs a bit less, and AMD's drivers don't have any serious pitfalls.

Intel's Arc GPUs have some other advantages, however, like their superior codec support. The new RTX 40-series and RX 7000-series graphics cards now have AV1 encoding support as well, but those cost far more than twice as much as the A770. Even then, the Arc encoding support often ends up being superior both in performance and quality. There aren't too many applications with AV1 encoding support yet, but we expect that number to grow in the coming years, so if you do a lot of video encoding, the Arc GPUs could be a good choice. But again, you can get the same codec support from the A750 or even the A380 if that's all you're after.

ASRock provides a modest overclock of the GPU, with a rated boost clock of 2,200MHz. In practice, it hits its peak clock speed of 2,400MHz in virtually every game we tested. The catch is that ASRock bumped up the power limits, and we measured an average use of 250–275W in many games. It's not a huge increase, but using up to 50W more power than Intel's A770 16GB Limited Edition while delivering slightly less performance again ends up as a questionable tradeoff. At least the ASRock card runs quiet, but then so do many of its competitors.

The fix for most of these complaints is simple: ASRock needs to drop the price. Until that happens, we'd look at the Intel A750 or A770 16GB, Nvidia RTX 3060, or AMD RX 6650 XT or 6700 10GB. Each ranks ahead of the A770 8GB in at least one key area. **–JARRED WALTON**

BENCHMARKS

	Arc A770 8GB	Arc A770 16GB	RTX 3060	RX 6700 10GB
10 Game Average	66 / 47	69 / 52	60 / 44	**72 / 51**
Borderlands 3	95 / 69	93 / 67	75 / 53	**107 / 72**
Control (DXR)	**54 / 33**	53 / 32	47 / 29	41 / 25
Cyberpunk 2077 (DXR)	28 / 14	28 / **18**	**30 / 18**	23 / 13
Far Cry 6	96 / 75	101 / 79	100 / 73	**124 / 86**
Flight Simulator	**70 / 50**	66 / 48	57 / 41	68 / 46
Forza Horizon 5	57 / 49	81 / 69	77 / 64	**95 / 76**
A Plague Tale: Requiem	**56 / 42**	55 / 41	43 / 31	54 / 39
Red Dead Redemption 2	**78** / 60	**78 / 62**	55 / 45	66 / 53
Spider-Man: Miles (DXR)	54 / 23	**59 / 46**	53 / 38	51 / 35
Watch Dogs Legion	70 / 53	74 / 58	65 / 49	**88 / 62**

Best scores are in bold. All testing conducted with a Core i9-13900K, MSI MEG Z790 Ace, G.Skill 2x16GB DDR5-6600 CL34, 4TB Sabrent Rocket 4 Plus-G, and BeQuiet! Dark Power Pro 12 1500W. Scores are average framerates at 1920x1080/2560x1440 ultra, with ray tracing enabled in Control, Cyberpunk, and Spider-Man: Miles Morales.

VERDICT

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ASRock Arc A770 8GB Phantom Gaming D

➕ **REWORK** Decent performance; AV1 support; runs quiet.

➖ **REHASH** 8GB VRAM; higher power; driver issues.

$329, www.asrock.com/

SPECIFICATIONS

Architecture	ACM-G10
Lithography	TSMC N6
Boost clock	2,200MHz
GPU cores	4096
Memory	8GB GDDR6
TFLOPS FP32	18.0
Bandwidth	512GB/s
TBP	275W
Connectors	HDMI 2.0b, 3x DisplayPort 2.0 10G

ASRock is one of just a few graphics card manufacturers willing to touch Intel's Arc.

A rare gaming monitor without any RGB lighting or skull logos.

Philips Evnia 27M2C5500W

Philips' Evnia gaming line makes a subtle debut

PHILIPS HAS been mostly absent from the pages of this magazine in recent years, but its new Evnia range of products, including mice, headsets, mouse pads, and this monitor, are tailored to the PC gaming crowd. Philips' approach is aimed at modern gamers who eschew the gamer aesthetic, meaning there's no RGB lighting, no skull icons, and none of the other 'gnarly' touches that usually adorn gamer gear. Instead, there's a cool, sleek look to this 27-inch, 1440p, 240Hz monitor—'understated' is the theme.

If you're a fan of the futuristic look and inoffensive grey coloring, then the 27M2C5500W makes a great first impression. It's easy to set up, with a tool-free stand that takes little room up on your desk and offers lots of flexibility in vertical height and angle for the display. The monitor itself is also pretty attractive, with thin bezels and only a small Philips logo on the chin, with the option to dim or turn off the power light in the settings. Our main complaint is that there's nowhere to feed the cabling through the thin stand to keep things nice and tidy, which feels at odds with the minimalist aesthetic.

Speaking of cabling, this is a monitor with excellent connectivity. There are two DisplayPort 1.4 and two HDMI 2.0 ports, so I was able to hook up a desktop, a laptop, a PlayStation 5, and an Xbox Series X all at the same time. There's also a USB 3.2 Gen 1 hub with four USB-A ports, two of which offer fast charging for phones. Again, that's more USB ports than you get on most gaming monitors. There's also audio in/out, although there are no speakers in the monitor itself.

There are two important things to bear in mind on this monitor—it's a VA panel and there's a 1,000R curvature. I mention these as some people will only consider an IPS (or now OLED) display, while others will prefer flat screens to curved ones. The VA panel has its drawbacks, in that it's not particularly bright and I encountered lots of ghosting when scrolling down web pages or documents. The text also became blurrier the more off-center I was—it's not a problem when sat straight-on at a desk but annoying all the same. HDR400 support is, as always, not really worth bothering with.

Those panel deficiencies are a shame, because otherwise this 27-inch, 2,560 x 1,440 monitor sits at the sweet spot for most people when it comes to size and resolution. The 240Hz refresh rate is probably more than most will need, but will please fans of fast-paced shooter games, nonetheless. The monitor is AMD FreeSync Premium Pro certified, and I was able to get my RTX 3070Ti to recognize it as GSYNC compatible, even though it's not officially supported.

The monitor also has a host of gamer-centric features such as a crosshair, picture presets for different genres, panel overdrive, and contrast boost. You can also do picture-in-picture, although in two weeks of testing, I couldn't figure out a worthwhile use for it. Perhaps if you want to work and watch some TV, or if you're streaming and want to play while keeping an eye on your broadcast? Either way, it's there if you need it.

This debut Evnia monitor is an encouraging first step into the gaming market for Philips, but not a total slam dunk. It has some great things going for it, with subtle styling, a wealth of inputs, and that sweet 27-inch/1440p combo that has mass-market appeal. But the VA panel suffers from ghosting, low brightness, and poor viewing angles. And while this Evnia is a good price, there are other monitors at this size, resolution, and refresh rate from the likes of Lenovo Legion that cost $100 less. Not a must-buy, then, but a decent first step from a brand to watch in future. **–GUY COCKER**

VERDICT

6

Philips Evnia 27M2C5500W

➕ **TOURNAMENT READY** Lots of ports; subtle styling; adaptive sync ready.

➖ **BACK TO TRAINING** Ghosting; limited viewing angles; no cable routing.

$499, www.evnia.philips

SPECIFICATIONS

Panel type	VA
Panel size	27-inch
Aspect ratio	16:9
Response time	1ms
Brightness	400 nits
Contrast ratio	3,000:1
Viewing angle	178º
Display colors	16.7M (8-bit)
Adaptive Sync	AMD FreeSync Premium Pro, G-SYNC compatible HDR: HDR 400
Maximum resolution	2560x1440 @ 144Hz (HDMI), 2560x1440 @ 240Hz (DisplayPort)
Ports	Audio (In/Out), 2x HDMI 2.0, 2x DisplayPort 1.4, 4x USB-A
Features	Kensington lock; VESA mount (100x100mm)
Weight	6.25kg (inc. stand)

The two glass panels on the
H9 Flow case are an extra
incentive to get your cable
management in check.

NZXT H9 Flow

A piece of art from NZXT?

WE WERE MORE than impressed by NZXT's H7 range of cases last year, and after using and reviewing all three of them, the Flow variant was the one that took our fancy. It offered the best bang for your buck, maximizing the potential performance of your build through its improved airflow while still retaining NZXT's clean design aesthetic. But does the same apply to the slightly larger dual-chamber H9 mid-tower cases? At the time of writing, there isn't a standard edition of the H9, just the H9 Flow we have here and the more expensive range-topping H9 Elite. The latter costs $80 more, so on paper, the Flow represents the better value for money, but is this the, er, case in the real world?

Compared with the H7 models we've already reviewed, the H9 has a deeper, wider, and taller design and also features two glass panels, which results in a see-through corner. This is one of the H9's stand-out features, differentiating it from the other models and setting it apart at the top of the tree. It's a great way to see all of your internals without the disruption from the typical metal corner you'd get on most cases. On the flip side, it's an extra incentive to get your cable management in check because you'll see every untidy power and SATA lead. In the black variant, NZXT uses tinted tempered glass, which suits the sleek design, whereas the white model features clear glass.

Another stand-out feature is the dual chamber layout. There's almost a false wall where the motherboard fits. Behind this is a cavernous space with plenty of channels for cable management, a vertical shelf for the PSU, and a hinged door to further hide cables around the back. There's plenty of room in the rear, so you won't have to squeeze your PSU cables as much as you might on other slimmer cases. We know this can often be a pain and can cause issues when trying to shut the back panel.

Talking of panels, these are easy to remove, which seems to be fairly typical with NZXT cases. The top panel pops off easily without requiring any tools, and both the front and back panels come off just by loosening a captive thumbscrew. Everything here feels durable and high quality. There are no alignment issues and each detachable part slots right back into place with ease.

Going back to the internals, there is so much room, enough for up to ten 120mm fans—that's a ridiculous amount of cooling, but perfect for those who need maximum airflow. Cooling combinations are plentiful inside here too, with the ability to mount a 360mm radiator to the side, top, and bottom.

There's also enough space to install either one of the latest Nvidia RTX 40 series or AMD 7000 series cards—you can see this for yourself in this issue's cover build. We installed Asus's Radeon RX 7900XT TUF Gaming card inside this H9 Flow, though one issue we did come across was finding a GPU mount solution. Our card came with an extendable bipod mount but it just wasn't long enough for this deep case. So bear this in mind when purchasing a GPU for this chassis.

That slight gripe aside, there's not too much to fault here with this chassis. There's also a healthy selection of I/O ports, no fiddly front panel connectors for the motherboard, tons of room to build in, a variety of configuration options, and dependable and durable build quality. Overall, it's a sleek looking chassis with the uninterrupted glass windows.

One problem we encountered wasn't a fault of the case itself, but more the packing materials it was shipped in. As soon as we picked it up out of the box, we were met with some lovely and welcoming static shock. Which is a timely reminder that, when building a PC, it's advisable to wear an antistatic wristband and work on an antistatic mat. Not only will it help you avoid shocks but, more importantly, you won't fry any of the internals!

Overall, this NZXT H9 Flow is a fantastic package, certainly when compared with its more expensive sibling, the Elite. However, that case comes with a top glass panel for those who prefer a full glasshouse design. On the other hand, the Flow variant offers much greater airflow to keep your system cool, especially with the potential of up to ten 120mm fans—all for $80 less. That's a significant price difference and you're getting all that you'll need here with this case. **–SAM LEWIS**

VERDICT

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KICK ASS!

NZXT H9 Flow

+ LAMINAR FLOW Great ease of use; dual-chamber design; premium build quality; lots of internal room.

– TURBULENT FLOW Hefty chassis; no built-in RGB lighting.

$160, www.nzxt.com

SPECIFICATIONS

Form factor	Mid-tower dual-chamber
Motherboard support	Mini-ITX, Micro-ATX, ATX.
Colors	Matte Black, Matte White
Window	2x Dark tinted tempered glass
Front I/O ports	2x USB 3.2 Gen 1 Type-A, USB 3.2 Gen 2 Type-C, 3.5mm headset audio jack.
Radiator support	Side up to 360mm with push/pull, Top up to 360mm, Bottom up to 360mm, Rear up to 120mm.
Fan support	Side 3x 120mm, Top 3x 120mm or 2x 140mm, Bottom 3x 120mm or 2x 140mm, Rear 120mm.
Graphics card clearance	435mm
Dimensions	19.4 x 18.3 x 11.4 inches
Weight	26.67lbs

BenQ Mobiuz EX480UZ
Go big (and pricey) with this 48-inch OLED monitor

HOW BIG IS TOO BIG for a gaming monitor? Competitive gamers prefer them small and fast, while single-player gamers tend to go big and colorful. The BenQ Mobiuz EX480UZ aims to cater to the latter group, combining all of the benefits of an OLED TV with the features of a gaming monitor.

The EX480UZ is a massive 48-inch 4K OLED screen with a refresh rate of 120Hz and support for HDR10. This monster OLED does a great job of making PC games pop while also offering the sort of insane scale that benefits cinematic, story-driven titles. The big difference between these large OLED monitors and similar TVs is connectivity. This has a more PC-friendly DisplayPort and two console-friendly HDMI 2.1 ports. It also has two USB 3.0 ports, a 90W USB Type-C downstream port to charge your devices, a USB Type-B port, and a S/PDIF jack. That's pretty impressive, though an extra HDMI port or two would have been handy.

The ergonomics of the Mobiuz aren't great as a PC monitor. The legs take up a lot of space, so you'll need a large desk to make this thing work. It also has a limited tilt, meaning you could have trouble finding a comfortable viewing angle.

Ideally, you want space between your face and a monitor of this size but with the Mobiuz being so huge, there's no way to safely push it back without it falling off most desks. That distance can make things uncomfortable for a day of working—sitting so close presents issues with text readability, even with text scaling applied.

That said, the Mobiuz deserves some praise in the looks department. *Spider-Man: Miles Morales* looks fantastic on this monitor, and as long as you have a powerful GPU to drive it, watching Miles zip around New York City in 4K at 120Hz never gets old. As always with PC gaming, HDR mode can be hit and miss—the contrast in *Hitman 3* and *Gears V* felt a little off in darker areas, but it didn't ruin the vibe. The anime-style *HiFi Rush* is a particular highlight though and felt like watching a Saturday morning cartoon.

There's a speaker bar at the bottom of the monitor, with 2.1 channels and a built-in 10W sub. It provides a decent enough soundscape and gives the Mobiuz some personality and visual flair, but we'd still look at using some dedicated speakers to complement a monitor this large.

A bigger issue is the price, with the Mobiuz listed at $1,699. Compared with OLED gaming TVs of that size, the LG C1 is cheaper at $1,300 and is often available for a lot less, plus it offers lots of apps and 'TV' features out of the box.

The BenQ Mobiuz EX480UZ is yet another large OLED that looks incredible and is fantastic for gaming, though it's a little impractical (and expensive) for most PC gamers. It has superb picture quality and a speedy response time, but its price and impracticality keep it from being a truly great monitor.

There are also several sizable 1440p 240Hz OLED gaming monitors due on the market, which feels like the current sweet spot for PC gaming. There's still a place for 4K 120Hz on screens of this size, but they also require RTX 4090 cards to drive them, something that means they are very much a luxury item for most.

The BenQ Mobiuz EX480UZ is a solid choice if you want to adopt the large gaming monitor lifestyle. It's got the speed, color, and contrast you want for PC and console gaming. However, its limited ergonomics and high price make it hard to fully recommend over some of its competitors. **–JORGE JIMENEZ**

VERDICT

7

BenQ Mobiuz EX480UZ

➕ **GO BIG** Great color and contrast; excellent response time; decent built-in speakers.

➖ **GO HOME** Expensive; poor ergonomic design; needs more HDMI ports.

$1,699, www.benq.com

SPECIFICATIONS

Screen size	48-inch
Resolution	3,840 x 2160
Brightness (peak)	450 nits
Response time	0.1ms GTG
Refresh rate	120Hz
Viewing angle	178° H&V
Contrast ratio	135000:1
Features	98.5% DCI-P3, adaptive sync, DisplayPort 1.4, 2x HDMI 2.1, USB Type-C, USB 3.0, Remote, KVM, HDRI Hotkey, Built-in speaker

© UNSPLASH

If you want a big screen for gorgeous OLED gaming, then this is it.

The Galaxy Book3 Pro 360 may not be the best value laptop, but you do get the benefit of its tablet function.

Samsung Galaxy Book3 Pro 360

All-around excellence from Samsung's flagship two-in-one

OUT OF THE LATEST Galaxy Book selection, this convertible model is the one that caught our attention. It's a conventional laptop but also features a tablet mode. Not only that, it contains the Galaxy S Pen, making this tablet great for use as a productivity device or for unleashing your creative side. For its $1,699 price tag, is this quirky device a better option than buying a conventional high-end laptop?

A quick look at this 16-inch laptop gives you an idea of how thin it really is. At just half an inch wide and weighing only 3.6lbs, it's light and easy to pick up and carry around. With this type of device being aimed at the creative and productivity market, portability is an important factor and the Galaxy Book3 Pro 360 makes light work of a daily commute. It's a sleek premium design, especially in the Graphite colorway we have on review here.

Open up the lid, and you're greeted by a huge and responsive trackpad that sits below the full ten-key keyboard. The keyboard is reminiscent of a MacBook, which isn't necessarily a bad thing for a productivity laptop. The keys have shallow travel that allows for quick typing, they're backlit and the power button on the board also doubles up as a fingerprint scanner.

Port-wise, there's a healthy selection of two Thunderbolt 4s, USB 3.2 Type-A, MicroSD, HDMI, and a 3.5mm headphone/mic combo. For a laptop this thin, that's more than enough. The MicroSD card slot is a useful addition for photographers and videographers. Also included is a Full HD 1080p webcam that produces decent results for everything from video conferencing to catching up with your friends, especially in tablet mode.

To get into tablet mode, simply fold the screen all the way around. Thanks to its subtle hinges, it folds completely flat to the back of the device, though, due to the thinness of the display, there is some screen wobble here. In tablet mode, it disables the keyboard and trackpad as your hands will be holding this side when using it as such. Here, the focus is on the Galaxy Book3 Pro 360's stunning AMOLED 3K touchscreen display. Even on boot-up, it's evident how rich the colors are—details are clear and the contrast is strong. You can also crank up the refresh rate to 120Hz in the settings, making this a silky-smooth display and giving it the feel of a premium product.

All of these features make it a great tablet for drawing. The laptop also comes with the Galaxy S Pen for use on apps such as Adobe's Photoshop, Illustrator, and InDesign, or even Microsoft's Fresh Paint, which means it's satisfying to use this device as a graphics tablet. Used in portrait mode, it's light enough to take notes, and though the stylus is accurate, our handwriting skills could do with some improvement here.

Underneath all this, the Galaxy Book3 Pro 360 has an Intel Core i7-1360P chip. With Intel's hybrid architecture, it boasts 12 cores, broken up into four performance and eight efficiency cores. Our Cinebench results scored well against the Lenovo Yogo Slim 9i —a strong performer in its own right. As well as this, the Galaxy Book3 Pro 360 gets 16GB of DDR5 RAM running at 6,000MHz and a 512GB SSD in this model. With read speeds of up to 6,743Mb/s and write speeds of up to 5,072Mb/s in our CrystalDisk benchmarking, it's a snappy drive, but a 1TB capacity would be preferable here.

As a productivity machine, the Galaxy Book3 Pro 360 has it all—a stunning display, two-in-one functionality, lightweight chassis, large trackpad, decent AKG speakers, and healthy battery life. However, for this price, be aware you can get more performance for your money. What you won't necessarily get is a 13th gen Intel chip and the convertible design that are the device's main selling points. But if you're after a tablet and a fully functional laptop, there's no better device around. **–SAM LEWIS**

VERDICT

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Samsung Galaxy Book3 Pro 360

➕ **GALAXY PRO** Thin, two-in-one design; stunning AMOLED 120Hz display; snappy transfer speeds; handy Galaxy S Pen included.

➖ **GALAXY NO** Slight screen wobble; not as premium feeling as similarly priced laptops; no discrete GPU for gaming.

$1,699, www.samsung.com

SPECIFICATIONS

CPU	Intel Core i7-1360P @2.20GHz
Graphics	Intel Iris Xe Graphics
RAM	16GB DDR5 @6000MHz
Screen	16-inch 3K (2880 x 1800) Multitouch AMOLED @ 120 Hz
Storage	500GB NVME M.2 2280 PCIe 4.0
Ports	2x Thunderbolt 4, USB 3.2 Type-A, MicroSD, HDMI, 3.5mm headphone/mic combo
Connectivity	Wi-Fi 6E, Bluetooth 5.1
Battery life	Up to 19 hours
Dimensions	0.5 x 9.9 x 13.9 inches
Weight	3.66lbs

BENCHMARKS

	ZERO-POINT	
Cinebench R23 Single-Core (Index)	1,243	1,800 (45%)
Cinebench R23 Multi-Core (Index)	9,826	10,370 (6%)
CrystalDisk QD32 Sequential Read (MB/s)	3,574	6,743 (89%)
CrystalDisk QD32 Sequential Write (MB/s)	2,193	5,072 (131%)
3DMark Fire Strike Extreme (Index)	5,442	5,610 (3%)

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

Our zero-point consists of the Lenovo Yoga Slim 9i laptop from our March 2023 issue, featuring an Intel Core i7-1280P, 16GB (2x8) of DDR5-5600, and 1TB PCIe 4.0 NVMe SSD. No manual CPU overclocking.

SteelSeries Apex 9 TKL

Is this keyboard an apex predator or bottom feeder?

TEN-KEY-LESS or TKL is often seen as the sweet spot for keyboard form factors. Not too big, not too small, and no messing around with function keys. They're compact enough so they don't hog all of your desk space, yet fast enough for a good gaming experience. However, if you work on spreadsheets or use the calculator app, then look elsewhere.

SteelSeries offers a range of TKL boards, the Apex 3 TKL we've reviewed previously, the Apex 7 TKL, this Apex 9 TKL, the Apex Pro TKL, and the range-topping Apex Pro TKL wireless. There's a lot to choose from, with prices ranging from $45 to $250. This Apex 9 TKL sits in the middle at $140, so is this the model you should focus your attention on?

When it comes to design and quality, SteelSeries definitely hits the mark. Even the cheaper Apex 3 TKL model boasts the brand's impressive style. As for this Apex 9 TKL, it has a clean all-black look with an aircraft-grade aluminum top plate. This provides great strength and long-term durability for the board. The main construction is hard plastic and the keys are made of double-shot PBT keycaps. The texture provides a decent grip on the keys for less split and more accuracy.

The Apex 9 TKL weighs 1.39lbs, which is a good weight without being overbearing or cheap-feeling. This gives it enough hold so it doesn't slide around on your desk. Underneath, there are also six rubber grips, two feet with adjustable height, and most notably, a hidden rubberized compartment that houses a keycap puller. That's a surprisingly handy feature, as we have lost our fair share of them over the years.

One thing that was disappointing was the individual readability of the keys.

The typeface is dark and it's hard to read under low light. Thankfully, it's an RGB board, but if you didn't want to use this feature, you may be left in the dark here. Talking about keys, what lurks underneath the PBT caps?. That will be the SteelSeries Linear OptiPoint Optical switches. Taking a closer look and using the keycap puller, these switches are technically Gateron Yellow optical linear switches with a 4mm travel and 35g actuation force. The actuation distance can be set to either 1mm or 1.5mm, which is a neat feature of this board. It's all configurable within the SteelSeries GG Engine application, which is a neat piece of software and must when using this board.

The switches are smooth and provide a sound on the lighter side of the scale, if anything a little too hollow-sounding for our liking. Performance is fantastic though, thanks to such a small actuation and low force requirement, and the lightning-fast properties of optical switches, these features make it suitable for high-tempo gaming in competitive settings.

Another notable feature is the media controls, found at the top right of the board. Considering the space available, they're small and, whereas on the cheaper Apex 7 TKL, you can find an OLED Smart display there, most of the space has been taken up by company branding. That board costs $130 and comes with a wrist wrest, but uses mechanical brown, red, or blue switches. For that price, it offers more, you just sacrifice a little performance on the Apex 7 due to the mechanical switches.

So is the Apex 9 TKL the board you should pay the most attention to out of

SteelSeries' current TKL range? If it's outright performance that you're after, then it's the second best beneath the Apex Pro, but those boards cost you an extra $40. If you require more features and can settle for the slightly slower mechanical switches, then the Apex 7 TKL offers more—and that leaves us in a rather tricky spot.

The price is our main issue with the Apex 9 TKL. It's a great board in its own right—it has a strong feel with tough double-shot PCB keycaps, and smooth and snappy linear optical switches, but there are tempting offerings from the same company on either side of this price point. It just depends on where your preferences lie. **–SAM LEWIS**

VERDICT

8

SteelSeries Apex 9 TKL

+ APEX LEGEND Double-shot PBT keycaps; smooth, linear, hot-swappable keys; keycap puller compartment; multimedia controls.

– APEX VILLAIN Lacking in connectivity; no wrist rest; no OLED display on cheaper models.

$140, www.steelseries.com

SPECIFICATIONS

Switch type	SteelSeries Linear OptiPoint Optical
Switch durability	100 million presses
Design style	TKL
Connection	Detachable USB Type-C
Wrist rest	N/A
Weight	1.39lbs

HyperX ProCast
Truly incredible sound… at a cost

SINCE LAUNCHING its first microphone in 2019, HyperX has produced a model to suit almost every type of content creator. This time around, the company is aiming for pro-level users with its first XLR microphone, the HyperX ProCast. What sets the HyperX ProCast apart is what's inside. It's got a gold-plated large diaphragm condenser capsule, which you'll find in many XLR mics used by professional musicians and podcasters. The result is deeper, richer vocals than you'd get out of your standard USB microphone.

Of course, nearly $250 is a lot of money to spend on a microphone, but when compared with other large diaphragm condenser microphones that aren't marketed to streamers, it starts to look like a more competitive price point. Bear in mind that the Elgato Wave DX currently retails for $100, although we haven't used it here on *Maximum PC* yet.

One surprising element is the lack of features and extras when you compare it to HyperX's other 'cast' mics. These include RGB lighting, an included stand, and a variety of recording modes. But it sounds good, and that's the priority here. ProCast delivers the stellar sound quality you'd expect from an XLR, and if that's what matters most, you should strongly consider spending the money.

At a glance, it keeps with the brand's clean cylindrical designs, ditching much of the visual flair apart from the red accented cords on the shock mount. Sadly, there's no tap-to-mute feature, which is one of the best features of other HyperX mics. But the ProCast is a sturdy piece of premium kit that feels as though it belongs in a studio.

As the ProCast is an XLR mic, you'll need an audio interface to plug into your PC, which is an extra expense. USB mics are easier to use because they are plug-and-play, but once you use an XLR mic and hear the difference, you'll probably be able to justify the expense. Even with a lot of upload compression, the ProCast's sound quality blows HyperX's best USB mic, the Quadcast S, out of the water. It doesn't even come close.

The ProCast produces a clear, clean sound that is best suited for content creators who talk a lot. If you're just chatting on Discord, there are cheaper options, such as the HyperX SoloCast we recently reviewed in our February issue. When playing *Warzone 2.0* online with this though, we had players asking what mic we were using, as it sounded so good.

SOUNDPROOFING NEEDED

The only issue with the ProCast is that it is pretty sensitive, even with gain adjustments, meaning it picks up background noise. So you'll need a room or booth setup with some soundproofing, and you may also want to switch on the 80Hz filter, which should help with unwanted low-end noise.

You'll also need a boom arm, as the ProCast doesn't come with a stand or an XLR cable. In fact, apart from the mic itself, the only accessory is a detachable, front-facing pop filter that's mostly serviceable. Though lots of XLR microphones come this way, it's still a little disappointing since HyperX's other streamer-focused microphones come with extras out of the box.

At this price, the ProCast goes up against the Shure M7, which is currently the gold standard in microphones because of its sound and the fact it's a hybrid XLR/USB mic. That flexibility could be important for many people, but thankfully, no matter which one you choose, both these mics sound great.

The HyperX ProCast is a great-sounding debut XLR mic that plays it safe design-wise. Your voice will sound its best, as long as you have the cash to spare on it and all the accessories. The ProCast sits at the top of HyperX's surprisingly diverse lineup of impressive podcasting USB mics as its first pro-level XLR offering. It's a great-sounding microphone, though one that lacks some of the versatility of other similarly priced USB microphones. **–JORGE JIMENEZ**

VERDICT

7

HyperX ProCast

➕ **STUDIO QUALITY** Great sound; sturdy build quality; sleek design.

➖ **GARAGE BAND** No desk stand; no lighting; fewer features than typical HyperX mics.

$250, www.hyperx.com

SPECIFICATIONS

Connectivity	XLR
Frequency response	20Hz–20,000Hz
Microphone type	Condenser
Polar patterns	Cardioid
Sensitivity	-38 dbV/Pa
Maximum input sound level	140dB
Noise (RMS)	-118 dBV
Dynamic range	123dB
Signal-to-noise ratio	75dB
Dimensions	5.3 x 4.0 x 8.2 inches
Weight (in shock mount)	0.83lbs
Warranty	2 years

SteelSeries Aerox 5

To be wired or not to be wired? That is the question

AFTER GETTING our hands (well, our right hand, at least) on the SteelSeries Aerox 5 Wireless not long ago, we were impressed by its ultra-lightweight, nine programmable buttons, pinpoint accuracy, and snappy wireless tech.

It wasn't perfect, though, and it featured some below-par RGB lighting and, more importantly, an RRP of $140. There was no creaking or rattling, but it didn't feel as premium as the price tag suggested and, unfortunately, the lack of weight—despite being one of the reasons it performed so well—resulted in it feeling a little bit on the cheap side. Regardless, we concluded that at a slightly lower price, it would make an excellent choice for your desktop.

Thankfully, there's a slightly lower priced variant of the same mouse, the non-wireless Aerox 5 model on test here. Aesthetically, it's almost identical to the wireless variant of the Aerox 5, for which we're thankful. It has the same ergonomic design that favors the palm and claw grip techniques. What hasn't improved significantly is the RGB—it just doesn't disperse evenly, and while underglow would have been more than adequate, it instead comes through the aerated upper part of the body.

Construction-wise, the mouse is made of ABS plastic, which combined with an aerated shell, brings the weight of the mouse to 1.14lbs. That's marginally lighter than the wireless variant, which we're assuming is down to the lack of the wireless receiver. This creates the only visual difference between the two, with this standard Aerox 5 ditching the wireless connectivity switch, of course. So all you get in the box is your typical small manuals and a detachable 2m super mesh USB Type-A to USB Type-C cord. It's excellent for reducing drag and providing a similar experience to its wireless sibling. Its PTFE feet play a part in this too as they glide effortlessly across your mouse mat.

Just like the wireless model, the Aerox 5 has nine programmable buttons. On the left-hand side, you will find a side button where your thumb rests, two side buttons typically for backward and forward in a browser, and above that is another button offering up and down functionality. On the top, you have your typical left and right-click buttons using SteelSeries's Golden Micro IP54 switches, a sturdy scroll wheel/button with plenty of grip, and a CPI button just below that.

You can take full advantage of these buttons in the SteelSeries Engine application by programming them to your liking—whether you have profiles for particular games or if you decide to use this mouse for creative work, this allows plenty of versatility.

SNAPPY RESPONSES

The performance of the mouse is determined by the SteelSeries TrueMove Air sensor. Co-developed by PixArt, this optical gaming sensor features CPI of up to 18,000 (with increments of 100cpi), 40G of acceleration, and a polling rate of 1,000Hz/1ms. All this can be tuned in the SteelSeries Engine to provide a snappy and responsive experience.

For eSports players, this is vital in a competitive setting, or if you're having a day off, it works for a spot of Solitaire too! Its feather-like weight, low drag cable, and PTFE feet means that flicking the mouse around your desk is a joy.

We're grateful for the detachable cable as, if this ever breaks (not that it should), you can easily swap it out. Or if you simply want to customize it by adding a longer cable to fit your setup, you can do just that.

So where does this leave us? Essentially, we have the same mouse as the Aero X 5 Wireless, just with more limited connectivity. That means great performance, solid build quality, great software versatility, and a nice detachable cable. The light weight of the mouse can make it feel less than premium, but the performance is great.

However, the RRP of this mouse is a much more appealing $80 and we have even seen it on sale for around the $60 mark. At this price, the Aerox 5 is a worthwhile pickup. The Wireless version may be the better mouse here, but the difference in price between the two makes the wired variant a much more viable option. –SAM LEWIS

VERDICT

9

SteelSeries Aerox 5

➕ **LIGHT WORK** Feather-like weight; durable, low-drag cable; nine programmable buttons.

➖ **LIGHT ISSUES** Below average RGB.

$80, www.steelseries.com

SPECIFICATIONS

Sensor	SteelSeries TrueMove Air
Sensitivity	18,000cpi
Polling rate	1,000Hz (adjustable)
Mouse switches	SteelSeries Golden Micro IP54 switches
Connectivity	USB Type-A to USB Type-C
Weight	0.14lbs

Win your fights and no one will care how many Italian towns you demolish in the process.

Company of Heroes 3

Relic's latest is a failed experiment, but a great game

WORLD WAR II still looms large more than 80 years after it all began—from school history lessons to cinematic epics. Even when we're looking for some video game escapism, it's there, making us replay the Normandy landings or the Battle of Stalingrad, deafening us with a cacophony of artillery and exploding tanks.

For *Company of Heroes 3*, developer Relic has taken us further south to the vineyards of Italy and the north African desert. And a lot has changed since the previous games, with the studio's ambition and desire for experimentation growing. This is something new, but it's not the novelties that impress the most.

Company of Heroes 3 is a beast of a game, cramming in two campaigns and four factions. Its proportions are fitting for this devastatingly massive conflict. The main course, ostensibly, is the Italian dynamic campaign—promising something akin to *World War II: Total War*. From Sicily to Rome, you'll push your way north, fighting the Nazis in random skirmishes and incredible bespoke missions. It's a huge turn-based campaign that serves up a slew of spectacular, tactically interesting RTS battles, and it should be the most exciting thing Relic has ever done. Lamentably, this is not the case due

to the absence of one crucial ingredient—it isn't remotely dynamic.

As an RTS, *Company of Heroes 3* is right up there with the best, but Relic's experimental campaign is a bit of a dud. Across our nearly 40-hour march to Rome, we encountered hardly any resistance. The only time an adversary attempted to take back a town we'd captured, it was a scripted event. Aside from that, the Nazis seemed resigned to letting me keep everything I'd claimed. Regardless of the difficulty settings, aggression appears to be a foreign concept to them.

If one of your companies encounters an enemy company, they will usually try to attack you after you've finished your turn. At the very least, they do appear to be willing to defend their territory, although they never go beyond that. This renders the campaign largely pointless, turning it into a perfunctory saunter. You'll be told to defend towns and build emplacements to help with this, but doing so is a waste of companies and resources when the enemy will never venture south.

The Italian campaign, then, is fundamentally broken, but we're less disappointed than expected. We were anticipating something grand, something evocative of *Total War*, and it doesn't

remotely live up to this and yet it spits out incredible fight after incredible fight. So many highs and thrills—and those explosions? Impeccable. Pristine maps turned into hellish, crater-filled nightmares, buildings crumbling, tank husks smoldering, men running around on fire—it's appalling but exciting.

Here, in the RTS layer, we see real dynamism. And it even gives a glimmer of dynamism to the campaign map, where bombing a location before you head into battle transforms it, pitting the ground and destroying buildings—which can have a dramatic impact on the ensuing fight. Once you enter the map, though, that's when you become a proper terraformer, remaking and deconstructing Italy's towns and countryside. The terrain reflects the decisions you make as you strategically take out anywhere Nazis might be hiding, as they do to you. Even the most stalwart cover is fleeting. When that 'Mission Completed' notification pops up, you celebrate amid the apocalypse.

The Hedgerow Hell and frosty Russian maps of *Company of Heroes 1* and *CoH 2* remain RTS high points, but Italy has spawned some of our new favorite fighting spots. Narrow roads surrounded by tall buildings, hiding snipers and
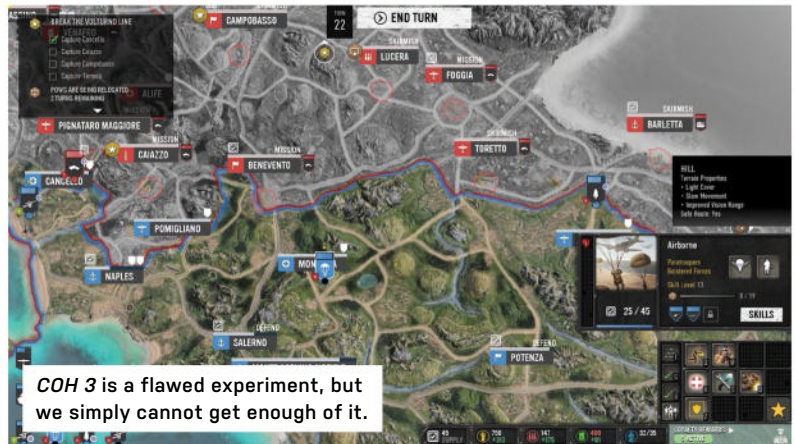
Prepare yourself for a cacophony of artillery and exploding tanks.

Each company has a unique style and different toys to play with.

The progression systems are, sadly, a bit of a tangled mess.

COH 3 is a flawed experiment, but we simply cannot get enough of it.

machine gun teams; winding countryside paths, where anti-tank guns hide behind every corner; the terrifying expanse of an airfield runway, where cover is a luxury and death seems perpetually imminent—even the memories of these encounters is enough to get the heart thudding like an artillery strike.

RANDOM SKIRMISHES

Between the big missions are countless random skirmishes, and given the length of the campaign, we were worried they might start to get a bit stale. That didn't prove to be the case, not just because there are plenty of skirmish maps and objectives, but because each type of company has a different style and different toys to play with, keeping things exciting, even 40 hours in.

The Indian Artillery Company remained a favorite throughout, however, calling in handy off-map artillery strikes, dropping powerful mortar teams into the battle, and letting us play with the badass Gurkha unit. These lads can toss a whole barrage of grenades at the enemy, and it's always a good time. If you like explosions—and if you're playing *Company of Heroes*, you must—you're going to have a blast with this company.

The much brisker north African campaign is *Company of Heroes* at its more traditional—a linear series of eight missions that sees you commanding the Deutsches Afrikakorps (DAK) and taking your marching orders from Rommell. The narrative is weird, attempting to balance the discomfort of playing as historical villains by interspersing it with stories of Jewish Berbers fighting against the Nazis or living in occupied areas. The attempt to tell less well-known stories, giving the oppressed a voice and even using their language, is a welcome one, but it feels awkwardly stitched together. Ultimately, it tells us stories about people that only exist in mostly static cutscenes.

The north African maps are also a big change of pace from their Italian counterparts. The frequency of the wide, open spaces initially makes them seem less tactical, but they are perfect for the DAK, a faction that's all about tanks. The desert really lets these behemoths rip, in turn emphasizing some of *Company of Heroes 3*'s new features, such as tank riding and side armor. Tanks are more versatile, but also require a bit more micro-management, blessing these fights with more tension, even as you ride into battle with the deadliest of monsters.

The two campaigns give you plenty of battles, but the multiplayer and skirmish modes extend that further, letting you fight other players or go on an old-fashioned comp stomp as one of the four factions (US Forces, British Forces, Wehrmacht, Afrikakorps). This quartet can then be further specialized in-game by picking specific battlegroup upgrade paths that reflect the companies of the campaigns.

Company of Heroes 3 is a hard game to render a verdict on. Patches may improve the Italian campaign, but it's impossible to look at it as anything other than a failure. And yet we've had weeks of fun with the RTS and can't wait to keep playing. It's a flawed experiment that has provided us with real-time brawls that we cannot get enough of. If you're willing to accept that the campaign is a vehicle for fantastic battles, you will love it too. **–FRASER BROWN**
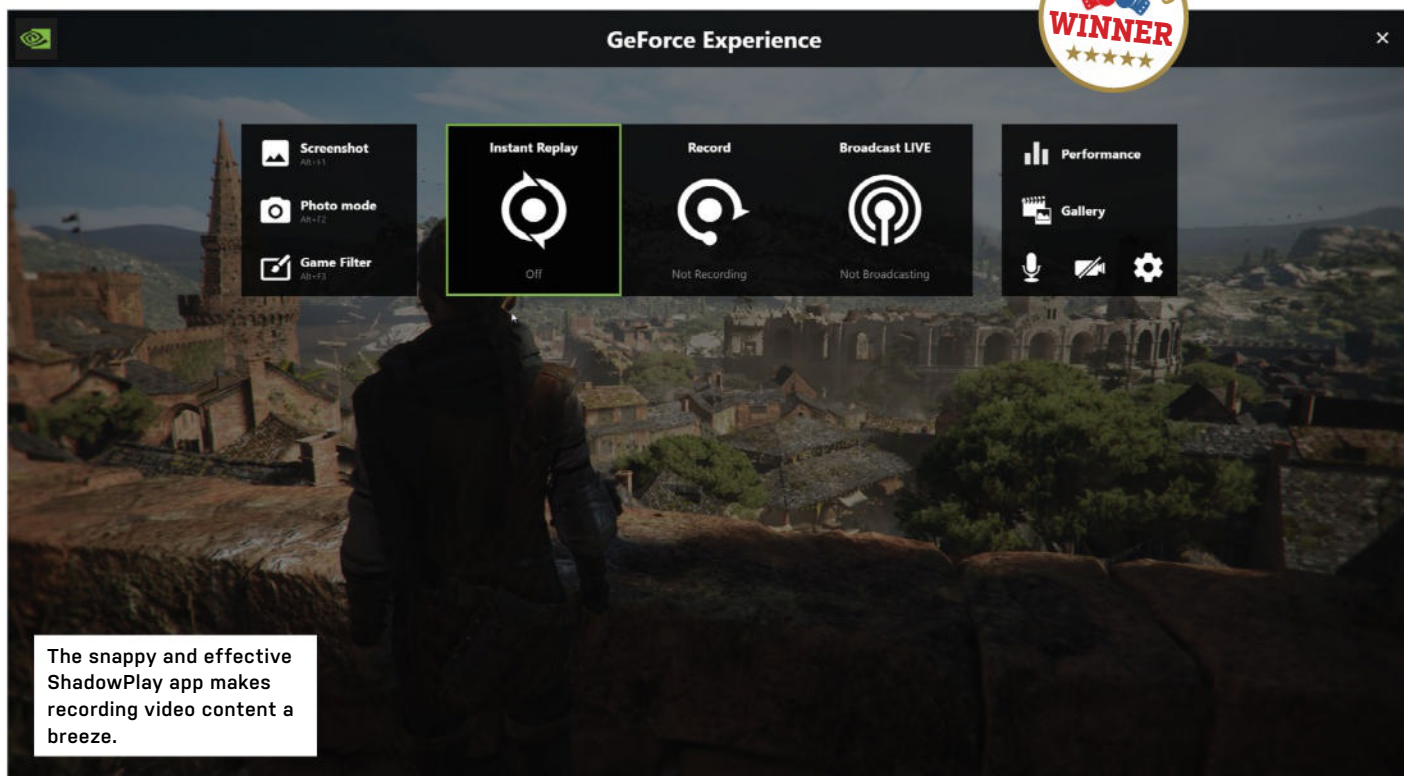
The snappy and effective ShadowPlay app makes recording video content a breeze.

ShadowPlay vs. Xbox Game Bar

Which is the better video capturing utility?

THERE ARE NOW A PLETHORA of screen recording apps available—the days when Bandicam was the preferred option are long gone. You can now use physical devices, such as USB or PCIe Express capture cards from the likes of Elgato or Avermedia, or you can use screen capturing software programs, such as Nvidia's ShadowPlay and Windows Xbox Game Bar. With features such as quick access overlays, performance monitoring, and social interaction options, these offer more than just simple video recording.

What was once a hardware-intensive and expensive way of creating content is now far more accessible and user-friendly. Not only do these apps offer an easy way to help you create content, but they're also highly polished pieces of software, well worth adding to your system. But which one should you choose?

In terms of design, Nvidia ShadowPlay and Xbox Game Bar look pretty similar. Both apps use a light UI, especially with the overlay functionality, which is perfect for seamlessly recording your gameplay. Having to keep swapping in and out of apps isn't ideal, so having shortcuts to open up each app and start recording is most effective.

Nvidia ShadowPlay comes within the broader Nvidia GeForce Experience Application. Once downloaded, head to the settings page and enable experimental features. Below that, enable the in-game overlay, which can be opened by pressing the 'ALT + Z' keys. Alternatively, you can press the triangular in-game overlay icon between the notifications and settings icons along the top bar within Nvidia GeForce Experience. With this open, you're greeted by a black and green overlay with a boxy design. Everything here is clear and easy to follow, making it great for quick decision-making on the fly. On the left-hand side are default options for screenshot (ALT + F1), photo mode (ALT + F2), and game filter (ALT + F3).

In the middle, there are three main options for recording and streaming. First, there's an instant replay mode. With this enabled, Nvidia records up to 20 minutes of your gameplay, perfect for grabbing footage you may have missed. In the middle is the most important of them all, the record feature. Click this and you get two pop-ups, one to start recording (ALT + F9) and the other to open up the settings. Here, you can change the instant replay length in different increments, it

also shows you how much storage space your recordings will take up.

You can alter the video quality, choosing between low, medium, high, or custom. In the custom option, you can choose the bit rate/Mbps. The last two settings are the resolution and the framerate of your recording. All of these give you plenty of versatility when recording your footage. To the left of the record button is the Broadcast Live option for live streaming. Again, click this to start (ALT + F8) or to enter the settings. These are almost identical to the settings in the record option, but you can also select a stream destination (either Facebook, YouTube, or Twitch) and custom overlays for your stream which you can open from here.

On the right side are performance settings to monitor your GPU and enable automatic tuning, and also the gallery where you can find your screenshots and recordings, which is handy for keeping things organized. Below that, there are microphone options, including push to talk, on or off, and a camera icon that lets you turn your webcam on or off. Last but not least, you get the main settings for ShadowPlay. Here, there are choices for your streaming HUD layout, a connect
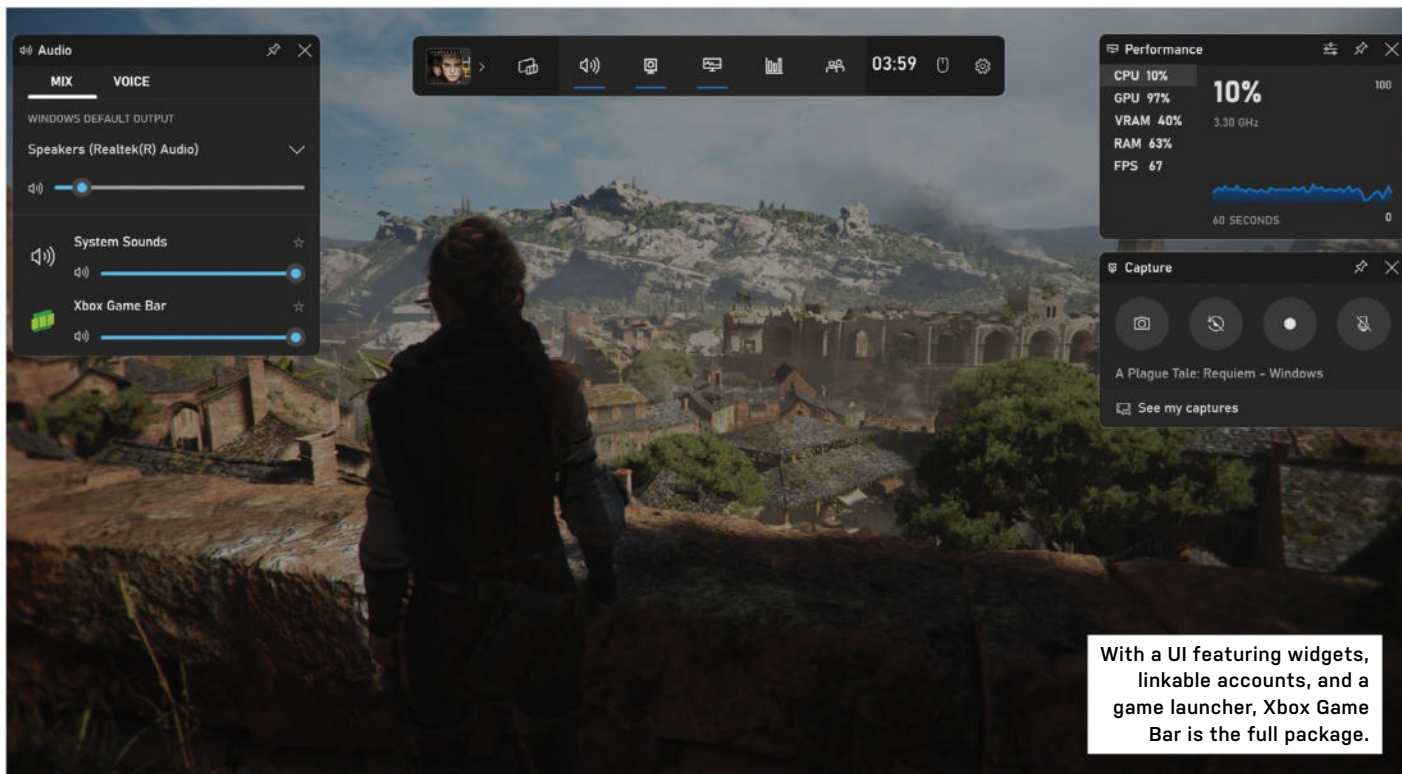
With a UI featuring widgets, linkable accounts, and a game launcher, Xbox Game Bar is the full package.

setting to sign in to accounts for streaming, keyboard shortcuts, further access to recording, broadcast, and photo mode or game file settings. You can also play with audio options, choosing your audio source and volume levels. The overlay is quick to open, simple to navigate, has great shortcuts, and when it's set up, easy to get recording or streaming.

BEST BAR NONE?

So how does ShadowPlay's rival, the Xbox Game Bar, compare? Unusually, the Game Bar ditches the Xbox green for a white accent design with more rounded corners than Nvidia's offering. In terms of features for the overlay, the two offer similar tools. To open the Game bar, press the Windows + G keys. The software is built into Windows 11, but if it's missing, install it through the Microsoft Store. Alternatively, in your Windows 11 settings, go to the Gaming option in the side menu, then select the toggle to open Xbox Game Bar using the Xbox controller home button. Once into the overlay, the standout point is the center game bar. This houses a controller bar (giving you access to your games and game launchers), the widget menu, audio, capture, performance, resources, Xbox social, the time, and a settings button.

Widgets work in the Xbox Game Bar just as they do within Windows 11 or an Android phone, for example. The Game Bar can be customized to your taste by

editing the UI with these widgets viewable by clicking on the widget button. On our UI, we added the Audio tab to the left, so that we can change the mixer and voice volume levels. To the right, we also added performance monitoring and, most importantly, the capture tab. This is where you can take a screenshot, replay, record, and mute your microphone. Like ShadowPlay, Xbox Game Bar has shortcuts for recording (Windows + ALT + R), capturing a screenshot (Windows + ALT + PrtScrn), and more. These are handy for capturing footage. Underneath, you can view all of your footage by clicking the 'See my captures' button.

In the settings, you can dive in even further to tweak the Game Bar to suit you. The personalization tab gives you more choices for a light/dark theme and transparency levels. You can also sign in with your social media accounts—here, you get more than Nvidia's ShadowPlay offers. As well as Facebook, Twitch, and YouTube, you can sign into Xbox, Steam, Twitter, Discord, and Reddit. This could be a deal breaker if you want to use the Game Bar with your account on one of these social media sites.

Other than that, there isn't much to separate these two overlays. The Xbox Game Bar tops it for outright design and customization, thanks to its smooth curved edges. Nvidia's ShadowPlay looks like it's stuck in the Windows 10 era and, while the fact it has less going on makes

the UI slightly easier, its resolution and quality features are accessible directly from the overlay, unlike the Game Bar. Go to the Windows settings, then Gaming and Captures to find them—however, there aren't as many options as ShadowPlay.

Although the Game Bar has more outright features and widget options, such as Spotify integration, when we were recording content and streaming, the Nvidia ShadowPlay overlay was quicker, had more in-depth quality control settings, and was our preferred choice, making it our winner here. But pick either of these and you won't be disappointed—they're both well-polished applications and best of all, they're free. –SAM LEWIS

VERDICT
9

Nvidia ShadowPlay

➕ **IN PLAIN SIGHT** Easy to navigate; detailed quality options; easy shortcuts.

➖ **IN THE SHADOWS** Fewer linkable accounts; Windows 10-esque design.

$free, www.nvidia.com

VERDICT
8

Xbox Game Bar

➕ **BRINGING YOUR A-GAME** Nice user interface; great social integration; customizable widget options.

➖ **GAME OVER** Awkward graphic settings; too many eggs in one basket.

$free, apps.microsoft.com

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LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> ## Z690 or Z790?
> ## Budget Build Needs
> ## Turbo Build Wants
> ## SK hynix lows

Missing Motherboard

I'm trying to build the 'budget' Intel build from the *Blueprints* section in the January 2023 issue of your great magazine. I've bought and received all the ingredients, apart from the ASRock Z690 Phantom Gaming 4/D5 ATX LGA1700 motherboard. The problem is, it's on back order and has been for about a month now from retailer NewEgg.

I'm wondering if you could recommend a similarly capable DDR5 motherboard. I can go up to a Z790, but I do not want to go backward. **—Dan**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: Thanks for the heads up on the stock shortages—I've updated Sam Lewis, who puts that section together. Having looked into this myself, it's still difficult to find an ATX LGA1700 DDR5 board for less than $200, which I assume is an important consideration in your budget build, and quite a bit more than the $156 board we recommended in the Jan issue. The only real candidate at the time of writing is the ASRock Z690 Steel Legend/D5 at $200, and currently available at the retailer you mentioned, NewEgg.

I can't personally recommend it as we've not reviewed it or used it in any of our builds, but as you were looking at an ASRock board anyway it will probably fit the bill. The comments I found online were pretty positive about the quality of the board, and it's a good deal cheaper than its Z790 equivalent, which is $290.

On a personal note, I've been putting together an Intel build myself this month, and having spent a lot on the Nvidia RTX 4090 GPU, I was keen to save a bit of money on the motherboard. I decided to go with the Gigabyte Z790 GAMING X AX at $240, which supports DDR5 and has the newer Z790 chipset.

As we've noted a few times in these pages, most people don't really need the features offered by Z790, but if, like me, you feel better getting a cutting-edge motherboard at a budget price, I'd recommend it. Equally, the ASRock Steel Legend is a well-specified board, albeit using a last-gen chipset. You can't go wrong with either, so let us know which you decide and how you get on with the build!

Budget Build Bonanza

I have to agree with R. Matlow, whose letter regarding "Not such a bargain" appeared in the February 2023 issue. $1,000 is not a budget build, especially for us non-gamers. Isn't *PC Gamer*, your sister magazine, the place for those sorts of builds?

I've adapted your budget builds for some of my previous setups by dropping the GPU and aiming the build toward the typical generic user.

The bottom line is—do as you suggested in your answer to the reader—aim for lower-end, non-gaming PCs in the budget builds. **—J. Francis**

Regarding the budget, midrange, and turbo builds in the back of the magazine, I would prefer to see these as 1080, 1440, and 4K gaming machines. This would be more useful to the reader, knowing how much to spend to get to the desired level of performance. **—R. Young**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: Well, as the old saying goes, you can't please all the people all the time. I've received many emails with feedback on what a 'Budget Build' should look like in 2023, with these two emails above being just a couple of examples.

If I were to summarize, there's a broad split between "a budget PC should be $600 or less" and "a budget PC should be $1,000 or less and suitable for 1080p gaming", with a slight popularity bias toward the former. I'm going to talk to our *Blueprints* maestro, Sam Lewis, and we will continue to evolve our ingredient lists over time.

↘ **submit your questions to:** editor@maximumpc.com

Personally, I'm of the opinion that sub-$1,000 is important, which was how this discussion originally started in these pages, and that if you want a cheaper PC or one that doesn't play games, just take the GPU out of the equation.

Thank you for all of your feedback though, it really does help inform what we do in future issues. Speaking of which…

Turbo Build Imbalance

Thank you for addressing my thoughts on the budget builds over the last few issues! Now, I want to move on to the Turbo builds—there is currently a $900+ imbalance between the AMD and Intel builds! This is mainly because you have the RTX 4090 in the Intel build and the much cheaper 7900 XTX in the AMD build. To even things out, it really seems like the Intel build should have an RTX 4080, but that's just me – I hate imbalance!

I also want to discuss the 40-series power connector issue, which is still on my mind as a long-term issue, even though Nvidia has addressed the short-term problem. The current cables are putting huge downward, rotational, and torsional pressure on the connector, which is made of soft plastic.

As the material heats up from I2R losses, the plastic will soften more, and the connector can unseat even if it's installed correctly. So, if Nvidia were to use thumb screw connectors, like we used to have with DVI, VGA, and other cables in the old days, it would ensure a positive connection that would not fail. I know that's not sexy, sleek, or easy, but it's the only surefire way to prevent this problem.

I also note that Next Cable Mod has custom 12VHPWR angled adapters coming out, and they can manufacture custom cable extensions for any 40 series GPU in their cable configurator. **–R. Matlow**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: Thanks again for your feedback on the *Blueprints* section, which seems to be the hot topic these last few issues! On the Turbo side, we definitely want to take a top-of-the-line approach. Not necessarily money-no-object, but the crème de la crème of both AMD and Intel-based builds. I'm sorry the resulting prices are a little different, but blame Nvidia for that and the 'enthusiastic' pricing of its cutting-edge cards!

And yes, you're right on the power connector issue on the 4090—along with the different weight-bearing solutions used by partner cards, they're just not all that elegant are they!? I'm sure better solutions will come out over time, and the performance is worth the installation pain, but I have to say, I do not look forward to the day when I have to remove or repair my 4090 and get it all connected back up again.

Righting Wrongs on Reddit

I was troubled by the reference in your review of the Noblechairs Legend on p78 of the February 2023 issue to a Reddit group called 'pcmasterrace'.

This kind of offensive antisemitism is really beneath what I expect from this storied publication. I do hope you look back at that line and see how ugly it reads. Frankly, even if this Reddit forum is the preeminent source for PC peripheral discussion, *Maximum PC* should have enough pride in its reputation to tell them to pound salt if that's what they want to call themselves. You uphold the legacy of *Boot*! You survived when *Byte* could not! Is this what you want to stand for?

I suggest you add an apology to your editor's note in an upcoming issue. **–D. Totten**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: Thank you for getting in touch with your feedback on this. I unreservedly apologize to Mr. Totten and anyone else who was offended by the reference. You are, of course, right to expect high standards from *Maximum PC*—it's a level that the whole team aspires to in every issue of the magazine.

You're also right to point out that while this particular subreddit may be a good source of information, it's incumbent on us as a quality publication to point out issues such as this and suggest that the community do better.

Thanks for giving us the opportunity to address this in this issue's *Comments* section, and it's something we'll bear in mind in future.

SSD Warranty Worries

I've installed five different SK hynix SSD and NVMe drives over the past two years. One of the SSDs failed last week, with something happening that meant it stopped writing. I could still read the drive, and, thankfully, recovered all of the data with the ddrescue tool.

However, I then had a rude awakening. The product information on Amazon indicates there's a five-year warranty, but SK hynix has no facilities in the US to handle customer replacements and Amazon only has a 30-day replacement policy. That means the warranty is reduced to 30 days.

Given this state of affairs, I'm now in the process of replacing all of my SK hynix drives as they have no warranty and I don't intend to have to deal with future failures when I can't recover the drive.

This is just an FYI that purchasing an SK hynix SSD or NVMe drive from Amazon gives you a 30-day replacement unless you pay more money for Amazon's outside agency.

Back to Corsair, Samsung, or WD for SSDs, I suppose. **–Patrick**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: This is an interesting letter because, as Jeremy Laird writes in *Lab Notes* this issue (page 72), Samsung has also been having SSD reliability issues of late. Samsung was once the gold standard in SSD reliability and performance but, as Jeremy says in his column, QA levels seem to be slipping, with multiple firmware updates needed for the company's new 990 Pro drives to date.

Anecdotally, I've also had a Samsung 980 Pro SSD fail on me after a few months of use, although to Samsung's credit, it was quick to replace it with a new one. This was especially generous, as I'd actually removed the drive from its heatsink. I bought the heatsink model because it was cheaper, but removing it techically voided the warranty.

On the SK hynix front, both Jeremy and I have used the manufacturer's drives for reviews, features, and builds, and have been impressed with their performance. I've tried to look into the warranty situation and it does appear that you're directed back to the retailer—in this case Amazon—for any returns issues. Thank you for your letter, because it is important to know that you can easily return a faulty drive if it breaks, as it's something I think most of us have experienced at one time or another. ⏻

THE BUILDS

THIS MONTH'S STREET PRICES...

BUDGET

OVER THE PAST FEW ISSUES, we've been focusing on bringing the overall price tag of both budget builds down back to a more reasonable 'budget' level. Last month, we got them below the $1,000 mark and with some further changes, they're down to around $800 this time. The challenge is maintaining the

performance level while finding cheaper or older components that are still in stock. At the time of writing, everything is in stock but this can soon change after we go to print, so we apologize in advance if it isn't. The same applies to any sale items that find their way into our builds as they run out quickly. Though correct at the time of press, sale prices can change rapidly too.

After changing lots of components in our Intel build, we were hit by a few price hikes this month. The Asus GeForce GTX 1660 Ti TUF Gaming EVO OC 6GB increased by $30, the Intel Core i3-12100 by $10, and the EVGA 450 BR Bronze 80+ Gold PSU by $15. Individually, these increases aren't too bad, but together, it all adds up to $55, which would be enough to double our RAM at least. Talking of RAM, we actually saved $10 here, so it's just a $45 increase. To reel back some of that cash, and partly due to a stock shortage of the EVGA 450W PSU, we swapped this out for an equivalent Corsair CV450W 80+ Bronze PSU that came in at $6 lower. That's enough for a few snacks to keep you happy while building this thing. Other than that, the build remained the same.

On the AMD machine, we applied the same PSU change as with the Intel budget machine. So it's out with the EVGA and in with the Corsair CV450 80+ Bronze PSU. Like the GPU on the other budget PC, the GPU also had a price hike from $199 to $225. So, we swapped out our Asus TUF Gaming OC Radeon RX 6500 XT 4GB for MSI's alternative RX 6500XT OC card and saved ourselves a huge $60. Apart from those two changes, the AMD budget machine didn't change all that much this time around.

AMD INGREDIENTS

PART		PRICE
Case	Corsair 4000D Airflow	$95
PSU	450W Corsair CV450 80+ Bronze **NEW**	$59
Mobo	MSI B550M PRO-VDH WIFI Micro ATX AM4 Motherboard	$119
CPU	AMD Ryzen 5 5600X	$155
GPU	MSI MECH 2X OC Radeon RX 6500 XT 4GB	$165
RAM	16GB (2x 8GB) PNY XLR8 Gaming EPIC-X RGB DDR4 @ 3200MHz	$50
SSD	500GB PNY CS2140 PCIe 4.0 M.2 SSD	$40
HDD	2TB Seagate Barracuda Compute 7200	$50
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32
Approximate Price:		**$765**

INTEL INGREDIENTS

PART		PRICE
Case	Corsair 4000D Airflow	$95
PSU	450W Corsair CV450 80+ Bronze **NEW**	$59
Mobo	ASRock B660M-HDV Micro ATX LGA1700	$95
CPU	Intel Core i3-12100	$140
GPU	Asus GeForce GTX 1660 Ti TUF Gaming EVO OC 6GB	$260
RAM	16GB (2x 8GB) PNY XLR8 Gaming EPIC-X RGB DDR4 @ 3200MHz	$50
SSD	500GB PNY CS2140 PCIe 4.0 M.2 SSD	$40
HDD	2TB Seagate Barracuda Compute 7200	$50
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32
Approximate Price:		**$821**

MID-RANGE

next few issues. With price increases across the board over the past year, we're having to go over each component with a fine-tooth comb while keeping everything compatible.

With our mid-range AMD build, we had a few price changes. Our AMD Ryzen 5 7600X fell in price by $10 but balancing that out, the ASRock B650M PG Riptide Wi-Fi Micro ATX AM5 motherboard went up by $10. However, both our Corsair Vengeance DDR5 and Crucial P5 Plus SSD fell by $5 each, which was a small victory. The only change we made was to our GPU. Out goes the ASRock Radeon RX 6750 XT Challenger Pro OC 12GB as we found an alternative Gigabyte Radeon RX 6750 XT Gaming OC 12GB on sale at $380. Another small saving, but every little counts. Overall, this machine now costs $1,410, down from $1,448.

On the mid-range Intel machine, we saw a few price differences on components from last time. Starting with our CPU, the Intel Core i5-12600K, a sale brought it down from $240 to $225. Our Corsair SSD, the MP600 PRO NH M.2 PCIe 4.0, also saw a hefty price drop from $105 to $85. Apart from that, we made two big changes, one for our GPU and one for our motherboard. Starting with the latter, we upgraded the previous Z690 ASRock Phantom Gaming ATX mobo to Gigabyte's Z790 UD AC ATX mobo due to stock issues with our old board. As for the GPU, that was also out of stock, so we swapped it out for another 3060 Ti, the Asus TUF Gaming 3060 Ti OC 8GB. This gave us a huge price saving of $131 and brought the overall cost of $1,651 from the previous issue down to a much more reasonable $1,498.

TAKING THINGS UP A NOTCH for our mid-range build, we have a little more cash to play with and can get a punchy machine at this price point. But, much like the budget builds, we've been aiming to bring down the overall price, so now both builds sit around the $1,500 mark, with hopefully some more cuts to come over the

AMD INGREDIENTS

PART		PRICE
Case	NZXT H7 Flow	$130
PSU	750W EVGA 750 BP 80+ Bronze	$90
Mobo	ASRock B650M PG RIPTIDE WIFI Micro ATX AM5	$185
CPU	AMD Ryzen 5 7600X	$240
Cooler	Cooler Master MASTERLIQUID ML240L RGB V2	$98
GPU	Gigabyte Radeon RX 6750 XT Gaming OC 12GB NEW	$380
RAM	32GB (2x 16GB) Corsair Vengeance DDR5 CL40 @ 4800MHz	$115
SSD	1TB Crucial P5 Plus NVME M.2 PCIe 4.0	$90
HDD	2TB Seagate Barracuda Compute 7200	$50
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32
Approximate Price:		**$1,410**

INTEL INGREDIENTS

PART		PRICE
Case	NZXT H7 Flow	$130
PSU	750W EVGA 750 BP 80+ Bronze	$90
Mobo	Gigabyte Z790 UD AC ATX LGA 1700 NEW	$195
CPU	Intel Core i5-12600K	$225
Cooler	Cooler Master MASTERLIQUID ML240L RGB V2	$98
GPU	Asus GeForce RTX 3060 Ti TUF Gaming OC 8GB NEW	$480
RAM	32GB (2x 16GB) Corsair Vengeance DDR5 CL40 @ 4800MHz	$115
SSD	1TB Corsair MP600 PRO NH M.2 PCIe 4.0	$83
HDD	2TB Seagate Barracuda Compute 7200	$50
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32
Approximate Price:		**$1,498**

TURBO

HERE COME THE BIG SHOTS, our turbo machines. Boasting good looks and powerful performance, these standout machines are where we're least concerned with cost. That said, it's still important to keep tabs on price changes so we can be sure we're getting the best value for money on the market.

One of the first components we focus on is the GPU. Typically the most expensive part of any build, they often dictate the overall cost. On the AMD front, our turbo machine houses the XFX Speedster MERC 310 Black Edition Radeon RX 7900 XTX 24 GB GPU and because the price didn't change, that stays. It's still the cheapest Radeon RX 7900XTX card available on PC Part Picker, boasting higher boost clock speeds of 2,615MHz compared to similar cards with speeds of 2,525MHz. Unfortunately, our second most important component, the CPU, went up by $24, though other parts and prices remain steady. Our ASRock X670E PG Lightning is still the cheapest X670E motherboard, the Corsair Vengeance DDR5 RAM is down by $10, the WD Black SN850X is down by $20, and our 6TB WD Blue HDD is up by $10.

Those components are also found in our Intel Turbo machine, so the same price changes apply. We bring in a new GPU, the Asus TUF Gaming GeForce RTX 4090 24 GB, which saves $181 on our previous Asus GeForce RTX 4090 TUF Gaming OC 24GB. And that's not the only great saving we made here—our monstrous Intel Core i9-13900K CPU falls from $600 to $560, bringing a combined saving of $221. We also brought the Z790 board that we included on our mid-range Intel machine—the Gigabyte Z790 UD AC ATX LGA 1700—over to this turbo rig, saving a further $15. Other than that, the rest of the build stays the same.

So then, how much do we save on both builds? With the AMD Turbo rig, we made a small saving of $34, but the Intel Turbo rig drops by $246. That's still nearly $680 more than the AMD, but most of that comes down to the cost of the RTX 4090 cards. Some things just don't change. Sigh!

AMD INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$190
PSU	1,000W Corsair RM1000 80+ Gold	$168
Mobo	ASRock X670E PG Lightning ATX AM5	$242
CPU	AMD Ryzen 9 7900X	$444
Cooler	Cooler Master MasterLiquid ML360R RGB 66.7 CFM 360mm	$145
GPU	XFX Speedster MERC 310 Black Edition Radeon RX 7900 XTX 24GB	$1,049
RAM	64GB (2x 32GB) Corsair Vengeance DDR5 CL40 @ 5200MHz	$240
SSD	1TB WD Black SN850X M.2 PCIe 4.0	$100
HDD	6TB WD Blue 5400 HDD	$100
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32
Approximate Price:		**$2,710**

INTEL INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$190
PSU	1,000W Corsair RM1000 80+ Gold	$168
Mobo	Gigabyte Z790 UD AC ATX LGA 1700 **NEW**	$195
CPU	Intel Core i9-13900K	$560
Cooler	NZXT Kraken X73 73.11 CFM 360mm	$185
GPU	Asus GeForce RTX 4090 TUF Gaming OC 24GB **NEW**	$1,619
RAM	64GB (2x 32GB) Corsair Vengeance DDR5 CL40 @ 5200MHz	$240
SSD	1TB WD Black SN850X M.2 PCIe 4.0	$100
HDD	6TB WD Blue 5400 HDD	$100
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32
Approximate Price:		**$3,389**

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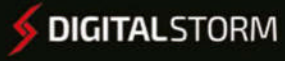Scan for paper facts, activities, blogs and much more!

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