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intel CHIPSET Z490

SUPPORTS intel CORE 10TH GEN

SOAR TO NEW HEIGHTS

AORUS Z490 GAMING MOTHERBOARDS

Z490 Product info.

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Tantalum Polymer Capacitors Array

The transient may occur while switching from lightweight scenario to power-hungry one, which leads to CPU clock fluctuation and affects user experience. Tantalum polymer capacitors array could improve the transient response and promises more stable platform for premium gaming or extreme multi-tasking.

50% Faster to recover from Transient situation, 22% Lower Voltage Spike ▲

THERMAL UPGRADE

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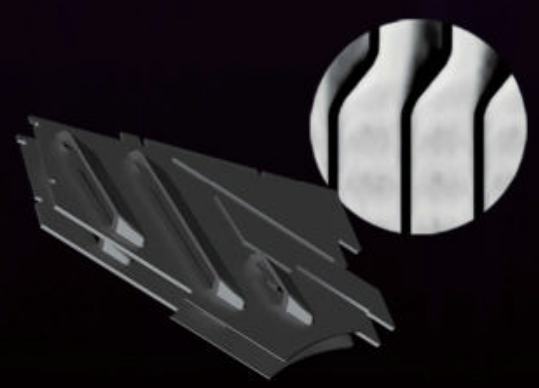
Direct Touch II / Fins-Array II

The heat-pipe has been enlarged for closer contact with heat-sink to improve thermal efficiency and additional 3 holes drilled on each fin in order to accomplish even better thermal capability.



Fins-Array II ▲

PERFORMANCE UPGRADE

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Xtreme Memory Technology

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Shielded Memory Routing ▲

9001

9000

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WARP SPEED Wi-Fi

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JULY 2020 #482

70

COMPLETELY FREE APPS TO MAKE YOU MORE (OR LESS) EFFICIENT

Intel strikes back

CAN 10TH-GEN CUT IT IN THIS AMD WORLD?

i9-10900K & i5-10600K IN THE LABS

+

Z490 MOTHERBOARD GROUP TEST

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BENCHMARK YOUR CPU
The *APC* Labs method

FUTURE

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XBOX ONE PS4 PC

XBOX ONE

CYBERPUNK 2077

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EDITORIAL

LET'S KICK THINGS OFF

EDITORIAL

Situation normal

Carry on.

It's on again. Intel vs AMD. The world is back to normal. Phew. I've missed this…

As Chris discovered through his long hours of testing fore this issue, Intel has indeed come back into the fight – though it's not a 'win'. Taking the lead in a few games with the usual single-digit percentage nose ahead isn't decisive, and for multi-core productivity work Intel is still playing catchup. Still stuck on the 14nm node, and still with an albeit evolved Skylake core that's been with us since the 6th gen, Intel has taken the relatively obvious route of cranking up the clocks with new and aggressive Turbo modes.

That makes sense. It's disappointing not to see a die shrink, or a new architecture, but it is pleasing to see that Intel's pricing is in the sensible zone, which is clearly a response to AMD's attack on the market when Zen 2 launched with up to twice the performance at half the price.

There are many that only trust Intel. There are many that have looked past AMD's Ryzen and Threadripper range thinking all the noise coming from enthusiasts around the world, and media reviews, and, *APC*, is just hype and AMD is still not to be taken seriously. The market says otherwise, though, which makes this 10th gen desktop launch such an important one for Intel.

"There are many that have looked past AMD's Ryzen and Threadripper range thinking all the noise coming from enthusiasts around the world, and media reviews, and, APC, is just background noise and AMD is still not to be taken seriously. "

Based on the Labs results we can see this isn't a slam-dunk for Intel, but it is still on the court and playing hard. Intel's strategy to milk its current technology and process is an obvious one. Improve the engineering (which it did in one area with a long overdue improvement to the thermal interface material used on these chips), and crank the clocks. That can't go on much longer though, so the fascinating game continues.

We went high-end this month with our CPU reviews, and in the next *APC* we'll be taking a close look at new budget chips, as we hit the Labs with the Ryzen 3100 and 3300X, along with a bunch of B550 boards to go with them.

Fun times are back, and it's nice to see it all play out. Hope you're all doing well. See you in a month.

BEN MANSILL

CORRECTION. In our review of the MSI Prestige 14 laptop in *APC 482* we mistakenly wrote that it has a GTX 1660 GPU. It is actually a GTX 1650 in this model. Pictured is the limited edition Prestige 14 Pink.

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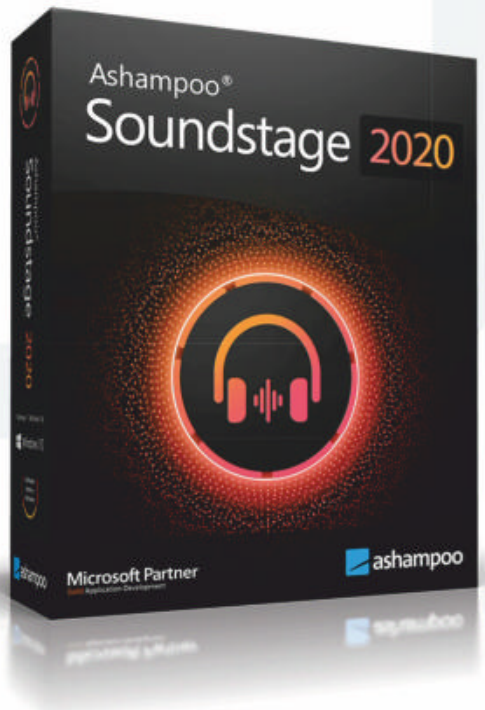

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Subscription enquiries:
(02) 8227 6486, future@crmaus.com.au

Editorial
Editor: **Ben Mansill** ben.mansill@futurenet.com
Senior Journalist: **Shaun Prescott**
Journalist: **Joel Burgess**
Journalist: **Harry Domanski**
Journalist: **Stephen Lambrechts**
Journalist: **Sharmishta Sarkar**
Creative Director: **Troy Coleman**
Designer: **Sharnee Swinnerton**

Contributors
Jonni Bidwell, Hope Corrigan, Alex Cox, Dr Ian Cutress, James Davenport, Ian Evenden, Wes Fenlon, Christian Guyton, Cliff Joseph, John Knight, Srivats Lakshman, Chris Livingston, Carrie Marshall, David Nield, Les Pounder, Nick Ross, Shashank Sharma, Tom Sykes, Chris Szewczyk, Mark Williams, Darren Yates

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Advertising
Group Advertising Manager: **Cameron Ferris**
cameron.ferris@futurenet.com

Management
Managing Director: **Neville Daniels**
Sales Director: **Paul Marttila**

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North Sydney, NSW 2059
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Email: apcmag@futurenet.com
Web: www.apcmag.com

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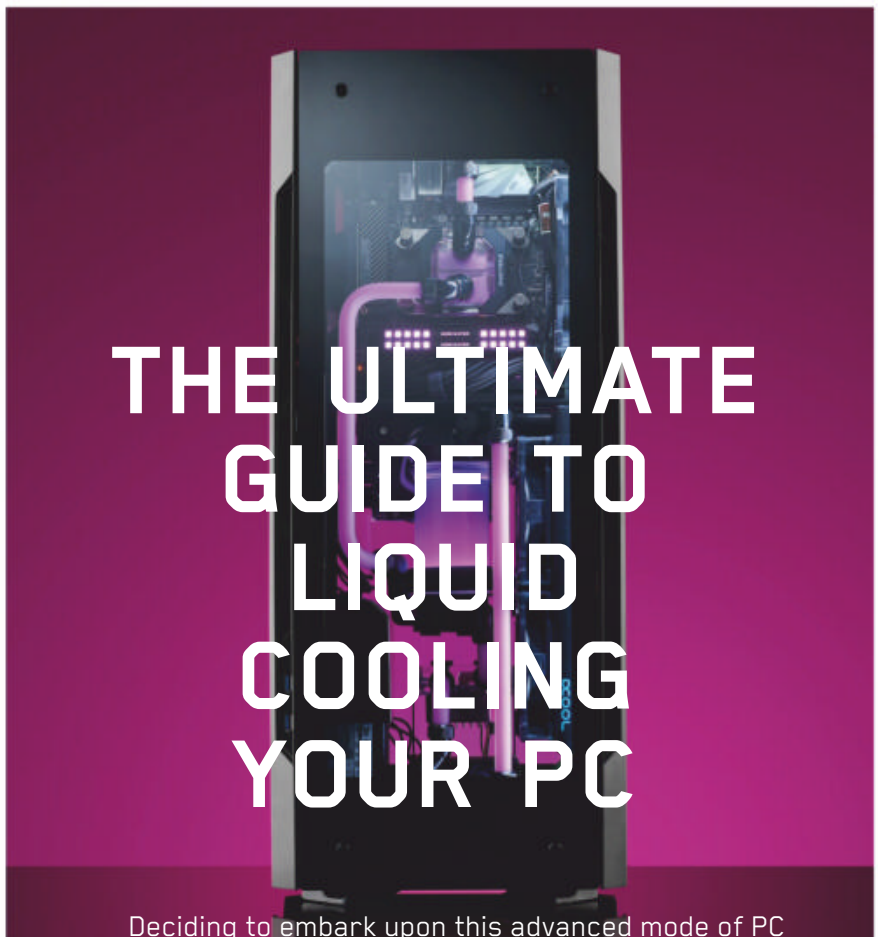

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Deciding to embark upon this advanced mode of PC building can be daunting. It requires in-depth knowledge of a vast multitude of parts, intricate experience and instinct that sometimes can't be taught. And, of course, there's plenty of room for failure

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TP-Link Archer AX50 AX3000 Wi-Fi Router

Bringing Wi-Fi 6 to the masses.

APC HOT PRODUCT

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APC RECOMMENDS

You will see this award if a reviewed product has scored four out of five stars. It means most people can expect satisfying performance from the product, and that we would use it ourselves.

Inside *APC*

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

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

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

Independent reviews

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

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

Labs testing

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

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

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

"APC strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible."

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TECHNOTES

ALL THE NEED-TO-KNOW TECH NEWS

Microsoft announces massive AI supercomputer

CLAIMS TOP 5 RANKING.

Microsoft has announced it's built a supercomputer hosted in its Azure cloud services, which it claims is among the top five supercomputers in the world. The announcement came at its Build 2020 developer conference in May, being hosted online due to COVID-19.

The supercomputer was built for OpenAI, a San Francisco-based artificial intelligence lab, and should be able to train large-scale AI models and make the framework for training them available to more developers.

Microsoft's computer is a system with "more than 285,000 CPU cores, 10,000 GPUs and 400 gigabits per second of network connectivity for each GPU server." That's enough, the company says, to rank among the top five in the TOP500 supercomputers list of the most powerful in the world. It has not, however, actually submitted its supercomputer to the site.

Project Reunion is Microsoft's attempt to get more Windows 10 apps

MORE TOOLS NO MATTER WHAT YOUR API.

Microsoft Build, the company's annual developer conference, is starting with a bold vision for Windows 10 development. It's called Project Reunion, and it will increase the effort to tear down the barrier between Windows API (Win32) development and the newer Universal Windows Platform (UWP).

The Project is supposed to "unify access" to both APIs and also make them accessible to developers separate from the operating systems. Microsoft's Kevin Gallo, corporate vice president of the Windows developer platform, wrote that this will occur with tools like NuGet, a package manager for .NET development. Additionally, Gallo wrote that apps can be modernised or get more features no matter how they're coded, including C++, React Native or .NET.

NETWORKING

Intel acquires Killer Wi-Fi owner Rivet Networks

Taking ownership of gaming networking.

Intel has acquired a rival in the Wi-Fi space. It purchased Rivet Networks, which makes the Killer-branded Wi-Fi cards and ethernet in gaming laptops from Alienware, Dell, Lenovo, HP and more. No price was disclosed when Intel announced the news via press release.

The Rivet Networks team will join Intel's wireless solutions group, a subset of Intel's client computing group. Intel will roll the Killer brand into its own Wi-Fi lineup. Rivet also produced the Killer-branded software that minimised latency and allowed users to prioritise which software got access to bandwidth.

"Intel will continue to sell Rivet Networks' software technologies and the Killer line of products to customers," an Intel spokesperson told Tom's Hardware. "Intel plans to continue the vast majority of Rivet Networks' existing products and services. Some minor changes may be made after full evaluation in alignment with Rivet Networks' customer commitments."

Intel has done manufacturing for Rivet Networks before, but now Windows PCs might have one less competitor in the field (and most premium laptops and gaming laptops were already using one or the other). In its press release, Intel wrote that it will "contribute to the developer ecosystem and deliver new value for our PC OEM customers."

Forget PS5: PCs with an RTX 2070 Super can handle Unreal Engine 5 demo

You'll also need an NVMe SSD.

Epic Games recently showed off its new Unreal Engine 5 demo, which blew us away with its impressive graphics. Running on an AMD RDNA-infused PlayStation 5 (PS5) it made console gaming – or at least its future – look exciting and promising. And just in time for the PS5 vs. Xbox Series X next-gen console war to start raging.

But what about the best gaming PCs? Did Unreal's demo prove that consoles are finally clawing their way to the gaming throne? We wouldn't bank on it yet. *World Today News* quoted Epic Games CTO Kim Libreri as saying the awe-inspiring demo will work "pretty good" on a PC running an Nvidia GeForce RTX 2070 Super graphics card. You'd also need a good NVMe SSD, (the PS5 also has an SSD).

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Intel offers insurance for unlocked 10th Gen Comet Lake CPUs

PROTECT YOUR CPU DURING OVERCLOCKING.

Intel has extended the coverage of its Performance Tuning Protection Plan (PTPP) to include the latest unlocked 10th Generation CPUs from the Comet Lake family. Intel devised the PTPP with the objective of providing enthusiasts with peace of mind during overclocking endeavours. Under the plan, Intel offers you one free replacement if you end up with a faulty or dead CPU as a result of overclocking.

Like in the past, Intel only offers the PTPP for unlocked Core i9, Core i7 and Core i5 parts. The PTPP is open to mainstream and HEDT (high-end desktop) processors. No matter which Comet Lake CPU you pick, the PTPP will cost you the same US$19.99, which is the same price charged for insuring Intel's 9th Gen CPUs.

Report: Nvidia Ampere, AMD Big Navi GPUs launching in September

IT LOOKS LIKE SEPTEMBER WILL BE THE MONTH OF GPUS.

A report from *DigiTimes* claimed that both AMD and Nvidia will launch their next generation of graphics cards in September. Giving the report more weight is a TrendForce press release in late May that noted that the release of new graphics cards, as well as the PlayStation 5 and Xbox Series X, will elevate DRAM demand and that "Nvidia and AMD are planning to release new GPUs in 3Q20."

Nvidia's GeForce RTX series received an update last year with the Super line, but these were, at the core, based on the identical Turing graphics architecture from the year before. Meanwhile, the AMD Radeon RX 5700 and RX 5700 XT will hit their first birthday in July, but the fastest card in the lineup still isn't as powerful as the Nvidia GeForce RTX 2070 Super, leaving AMD fans hoping for a faster, stronger RDNA-based card. Big Navi will reportedly be powerful enough to run the latest titles at 4K resolution and 60 frames per second.

CRYPTO

Upset investors accuse Nvidia of masking US$1 billion in mining GPU revenue as gaming

Cryptocurrency, the gift that keeps on giving.

Nvidia is getting sued by some upset investors who claim Nvidia mislead them by reporting crypto revenue as gaming revenue, according to a report at *The Register*. "Sales data demonstrated that, throughout 2017, 60% to 70% of Nvidia's GeForce revenue in China came from sales to crypto-miners, not gamers." reads the complaint. Such figures are similar elsewhere around the world.

Analysts say that the under-reporting of GPUs for the crypto market lands somewhere around the US$1.13-billion mark, and when the crypto mining market started showing signs of bust, Nvidia's stock price also dropped significantly.

Of course, you're probably thinking something along the lines of, "But the GPUs were gaming hardware, what's wrong with putting them in the books under the gaming division?" We wouldn't blame you for thinking this, but the investors disagreed. According to the complaint, Nvidia specifically marketed the GPUs for mining, and with the sales data available, it's clear where the GPUs were going. The issue the investors had was that Nvidia wasn't reporting this data, rather stating that its GeForce division was strong and that it would maintain stability once the crypto bubble cooled down.

China pumps US$2.2B into local chipmaker after US takes TSMC from Huawei

SMIC will have to step up.

The *South China Morning Post* reported that China has injected a hefty sum of money into Semiconductor Manufacturing International Corporation (SMIC), the country's largest domestic chipmaker. The US$2.2 billion investment comes on the heels of Nikkei Asian Review reporting that Taiwan Semiconductor Manufacturing Company (TSMC) isn't taking any new orders from Huawei.

In May the U.S. Department of Commerce announced restrictions that limit "Huawei's ability to use U.S. technology and software to design and manufacture its semiconductors abroad" and "cuts off Huawei's efforts to undermine U.S. export controls."

Given the ongoing tension between the U.S. and China, this wasn't too surprising. Huawei had already reportedly put in significant 14nm orders with SMIC. Citing a source familiar with the matter, *Nikkei Asian Review* reported that orders placed before the ban shouldn't be affected, and TSMC will ship those orders before the middle of September.

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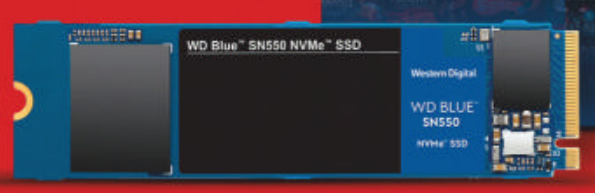

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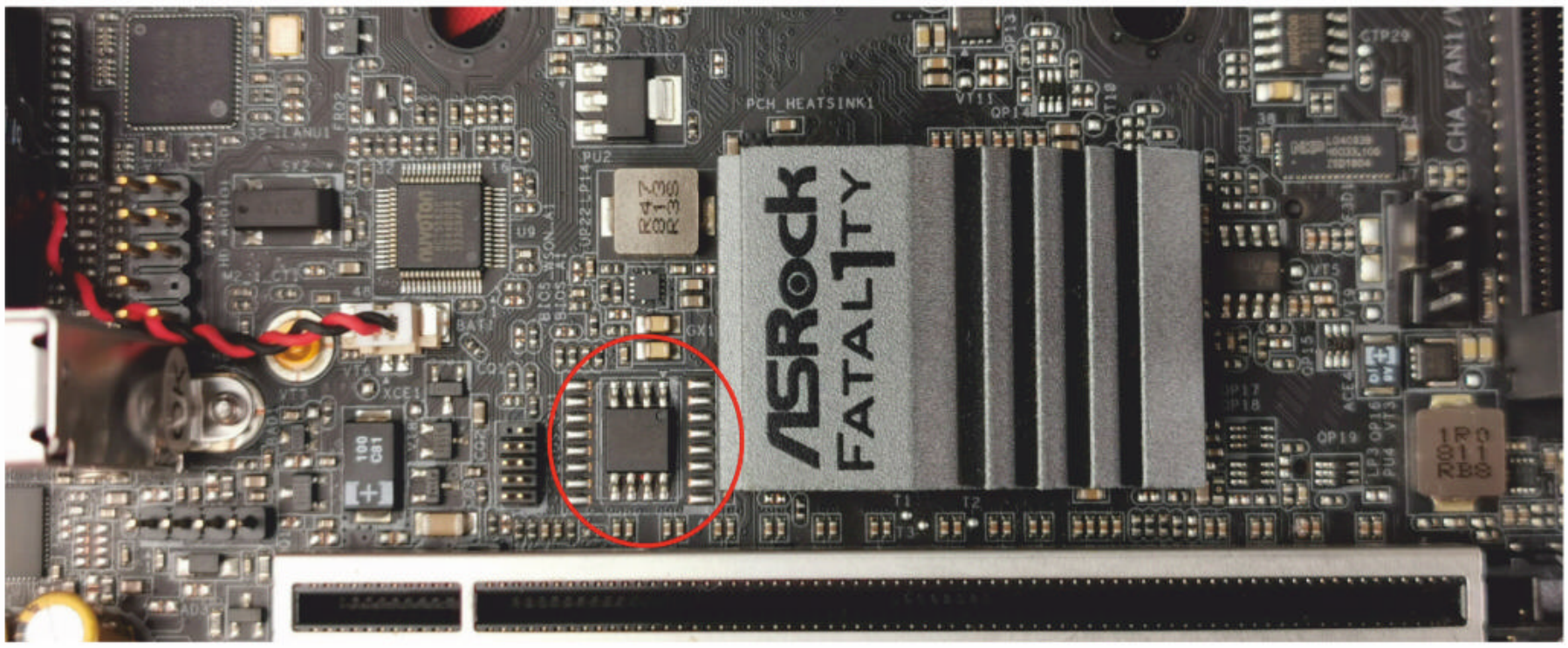

TECH BRIEF

AMD backflips after backwards-compatibility uproar

Will now support Zen 3 and Ryzen 4000 CPUs on B450 and X470 motherboards.

In a surprising twist, AMD has announced that it intends to enable Ryzen 4000 and Zen 3 support on its older B450 and X470 motherboards. This is going to be a 'promise now, figure out the details later' arrangement, but this should enable most (if not all) users running 400-series AMD motherboards to upgrade to the Zen 3 processors set to be unveiled later this year.

The situation all started after AMD launched the Ryzen 3 3300X and Ryzen 3 3100 processors, and also gave users details about the upcoming B550 chipset that these processors were targeted for. Part of that announcement included a chart, showing how due to BIOS limitations, certain chipsets would only support certain AM4 processors. X570, for example, would support previous Ryzen 2000, current Ryzen 3000, and future Ryzen 4000 processors – it did not support the original Ryzen 1000 processors.

On that chart, it was noted almost immediately that there was a glaring omission. AMD's B450 and X470 motherboards were listed as supporting Ryzen 1000/2000/3000, but not the future Zen3-based Ryzen 4000 processors. This made a number of users immediately very concerned, especially if they had purchased a B450 or X470 motherboard with a Ryzen 3000 processor with the hope to upgrade it in the future.

AMD came under a lot of fire. The company had originally promised that it would support the AM4 platform from 2016 through 2020 (or 'through to' 2020). A lot of users had assumed that this meant any AM4 platform based motherboard would be able to accept any processor made from 2016 to 2020, including the new Zen 3 processors set to be unveiled later this year. The fact that there was a discrepancy between what the users expected and what AMD had been saying essentially became a miscommunication or a misunderstanding, but one that had a negative effect on a number of users who were expecting to upgrade the system.

AMD responded after a few days of uproar with a statement that included "We've heard our audience, and we understand the concerns. We are going to work out a way to support Zen 3 on our 400-series chipsets between now and launch – we're still working out the what and the how, but we will update you closer to Zen 3 launch".

They are acknowledging that they perhaps misread the situation from its user base. Part of this issue stems from an old CPU line not having the growth room, and the believed that pushing support for Zen 3 to the 500-series wouldn't be that big of an issue. Now that they see it is, they will try to make it work. They will attempt to address the technical challenges, and even though they do not have all the details at this time, it will be worked on.

There is still 6+ months, perhaps, until we see Zen 3, so AMD does have a lot of time to try things and to test things. ■

DR IAN CUTRESS

AMD AM4 motherboard support

	UARCH	A320	B350, X370	B450, X470	X570	B550
RYZEN 4000 CPU	ZEN 3	NO	NO	BETA	YES	YES
RYZEN 4000 APU**	ZEN 2	NO	?	?	?	?
RYZEN 3000 CPU	ZEN 2	NO	BETA	YES	YES	YES
RYZEN 3000 APU	ZEN+	YES	YES	YES	YES	NO
RYZEN 2000 CPU	ZEN+	YES	YES	YES	YES	NO
RYZEN 2000 APU	ZEN	YES	YES	YES	NO	NO
RYZEN 1000 CPU	ZEN	YES	YES	YES	NO	NO
ATHLON A-SERIES	*	YES	NO	YES	NO	NO

* Excavator or Carrizo

** Unknown - product not announced yet

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OPINION

APC'S EXPERTS COVER THE HOT TOPICS

END USER

Social media platform holders are trying to make their sites less hellish

Small iterations in design probably won't fix the core of social media's problems, writes Shaun Prescott.

The past decade has been a wild ride for social media. In 2010, Facebook had amassed 500 million users and had easily usurped its hapless predecessor, MySpace. In the wake of Facebook's success several other platforms have become permanent fixtures in our social lives: Twitter, Instagram, and more recently, TikTok, have an influence on culture and politics that would have seemed unlikely just ten years ago.

The internet has never been a benign place, but it's easy to remember the early days of Facebook with fondness: "fake news" had yet to be coined, the NSA and Cambridge Analytica scandals were years and years away, and the emergence of the "like" button had yet to gamify our social interactions. Social media as a net positive, as a way of "bringing people together" is a sentiment that has well and truly eroded.

Platform holders understand this. While sites like Twitter and Instagram have always allowed private accounts, they've otherwise remained freewheeling, driven by the (perhaps already antiquated) belief that social media should connect people, not atomise them. But it doesn't take daily or hourly exposure to Twitter to see how it can be an exceptionally toxic place. Whether social media has bred society's increased polarisation, or merely reflected it, is an argument for another day. What's clear is that social media platforms are worried about it.

In May, Twitter introduced a new feature allowing users to limit comments on the tweets they publish. While this has some obvious practical uses (for example: it makes it possible for news services to conduct curated interviews on the platform), it can also be used to filter out any toxicity. By the same measure, it can effectively filter out dissent. It's an interesting step: Twitter has made a (admittedly small) step towards becoming a publishing service rather than a modern discussion board. Letting people "have their say" was the kind of thing social media was first lauded for facilitating. Turns out, letting people say whatever they want doesn't appeal to everyone.

Of course, online bullying is a very real and very dangerous phenomenon. But selectively turning off comments, or filtering who can reply, risks turning an already combative platform into one rife with unchallenged declarations: remember, Donald Trump has 80 million followers on Twitter, and he uses it a lot. A move to combat toxicity, while well meaning, can have some fairly undesirable results.

That may not hold true as much for Instagram, which depending who you talk to, is both the most dangerous and benign of the major social media services. In May it rolled out a series of changes centered around eliminating bullying: users can now control who tags them in posts, who mentions them in comments, and it's now possible to mass delete comments on one's own photos. But a change made to Instagram in 2019 was more telling: it blocked users' ability to see what their friends have 'liked'. This demonstrates more than anything that one of the core problems with Instagram is social anxiety.

Will anything ever fix social media? Probably not. The days of the liberal press celebrating it as a liberatory technology (think the Arab Spring) are long behind us. It's probably for the best to get out while the going's good. But is the going good? Did you read this article without checking your phone? ■

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

"Social media as a net positive, as a way of "bringing people together" is a sentiment that has well and truly eroded."

Conspiracy theorists are convincing people that Bill Gates invented the coronavirus

Bill Gates has been blamed for Ebola, the Zika virus, and for developing a new bioweapon called Disease X, but conspiracy theorists seem to have finally achieved some traction in blaming him for the COVID-19.

Back in *APC 478* we covered the claims by right-wing US YouTuber and QAnon supporter Jason Sather that the Bill and Melinda Gates Foundation had developed, patented and intentionally unleashed COVID-19 onto humanity as part of a global conspiracy, but we didn't expect this niche outbreak of lunacy to actually survive, let alone grow into what it has become today.

As it stands, northern Italian politician Sara Cunial made a speech on the parliament floor and then posted it to her Facebook page in early May condemning Bill Gates as a criminal, and calling for him to face the International Criminal Court for crimes against humanity. Soon after, more than 100 protesters from the 37,000 member Facebook group '99% unite Main Group' gathered on the parliament steps in Melbourne to voice concerns about 5G towers, vaccinations, the possibility that the government was microchipping citizens in order to control their minds, all while chanting the mantra 'arrest Bill Gates'.

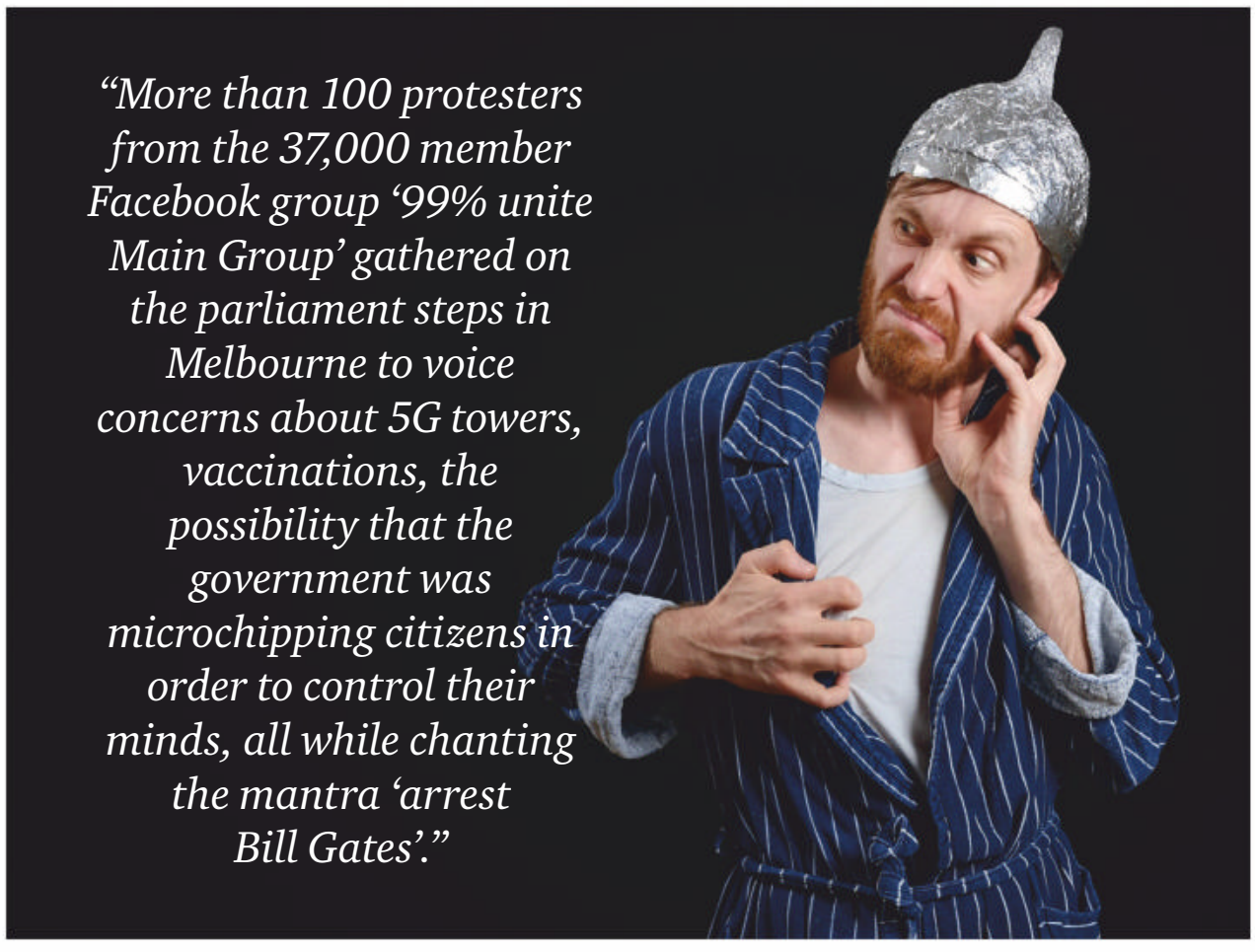
These beliefs may seem like the views of extreme minorities that will be rendered absurd by most people, but in an age of social media amplification, small minorities can actually find a lot of like-minded people, and have the potential to sway many more. Currently there is a petition on the White House's official page for citizen input that calls for the Bill and Melinda Gates Foundation to be investigated for medical malpractice and crimes against humanity... with over 576,000 signatures. A recent poll done by *Yahoo News* and YouGov in the US found that 44% of Republicans believe that Bill Gates is using the coronavirus outbreak to implant microchips in people to monitor their movements. And if you look at the other side of the fence, 19% of Democratic respondents in the survey also seemed to think that narrative is perfectly reasonable.

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

While this state of public opinion has thrown doubt on the potential to be able to effectively administer a COVID-19 vaccine – if we ever manage to develop one – it also shows that there is a genuine groundswell ready to let Bill Gates take the fall for creating a virus he has been working hard to protect the world against (at his own cost) for many years now.

While we've dealt with the 2018 avian coronavirus vaccine issue in ChipChat previously (*APC 478*), we should quickly explain the narrative that has led to concerns that Bill Gates is trying to control the population. According to a *Buzzfeed* deep-dive, a disgruntled employee involved in a Depo-Provera contraceptive clinical trial in Ghana (partially funded by the Bill and Melinda Gates Foundation) claimed, without evidence, that patients had been abused and that the crux of the experiment was broad population control.

While Ghanian health officials described the claims as libel, the baseless narrative was perpetuated locally and in the US via a report by the US group the Rebecca Project for Human Rights. This report was written by the partner of the Depo-Provera employee who brought the original claims, so while it could appear that there are at least morsels of truth in this narrative – a brief critical look at the evidence shows that it is, of course, utterly absurd.



TWO BITS

CPU socket compatibility and longevity

Is it all it's cracked up to be?

In our News Brief this issue (page 16), we wrote about AMD's off and on again support for its future 4000 series Ryzen processors on B450 and X470 motherboards. This got me thinking about the issue of platform longevity. Is AMD's approach of long term support with caveats the way to go? Or Intel's with its recent trend of a maximum of two generations? The answer is of course, somewhere in between, but definitely closer to AMD than Intel!

AMD has a long standing practise of promoting forward and backward compatibility for its ageing AM4 socket. You could theoretically run a 3950X processor on an A320 motherboard that has a very basic VRM and no heatsink, but it's the kind of pairing that won't end well. This is a part of the problem. There's a little too much compatibility.

A problem AMD faces is that many standard BIOS chips have a capacity of 16MB. That 16MB has to contain all of the firmware required to run the system, fancy UEFI interfaces and graphics, as well as contain code that allows the system to detect one of the 100+ different AM4 CPUs. AM4 has been around for long enough that these 16MB ROM chips run into limitations.

A simple and obvious solution would be to increase the size of the BIOS chips. On later AM4 models, you will find 32MB chips, but in an industry where every cent matters, 32MB chips weren't foreseen as necessary in the early AM4 days, clearly a mistake that's now apparent. Over the life of AM4, we've seen some of the early non Ryzen AM4 CPUs have their support dropped due to these space limitations. At the other end of the market, we see X570 not supporting 1st Gen Ryzen. It's a bit all over the place and it's only going to get more confusing when 600-series motherboards and 4000-series Ryzen launches later in the year. Is my product supported or not? It makes the whole AM4 long term support reputation a misnomer.

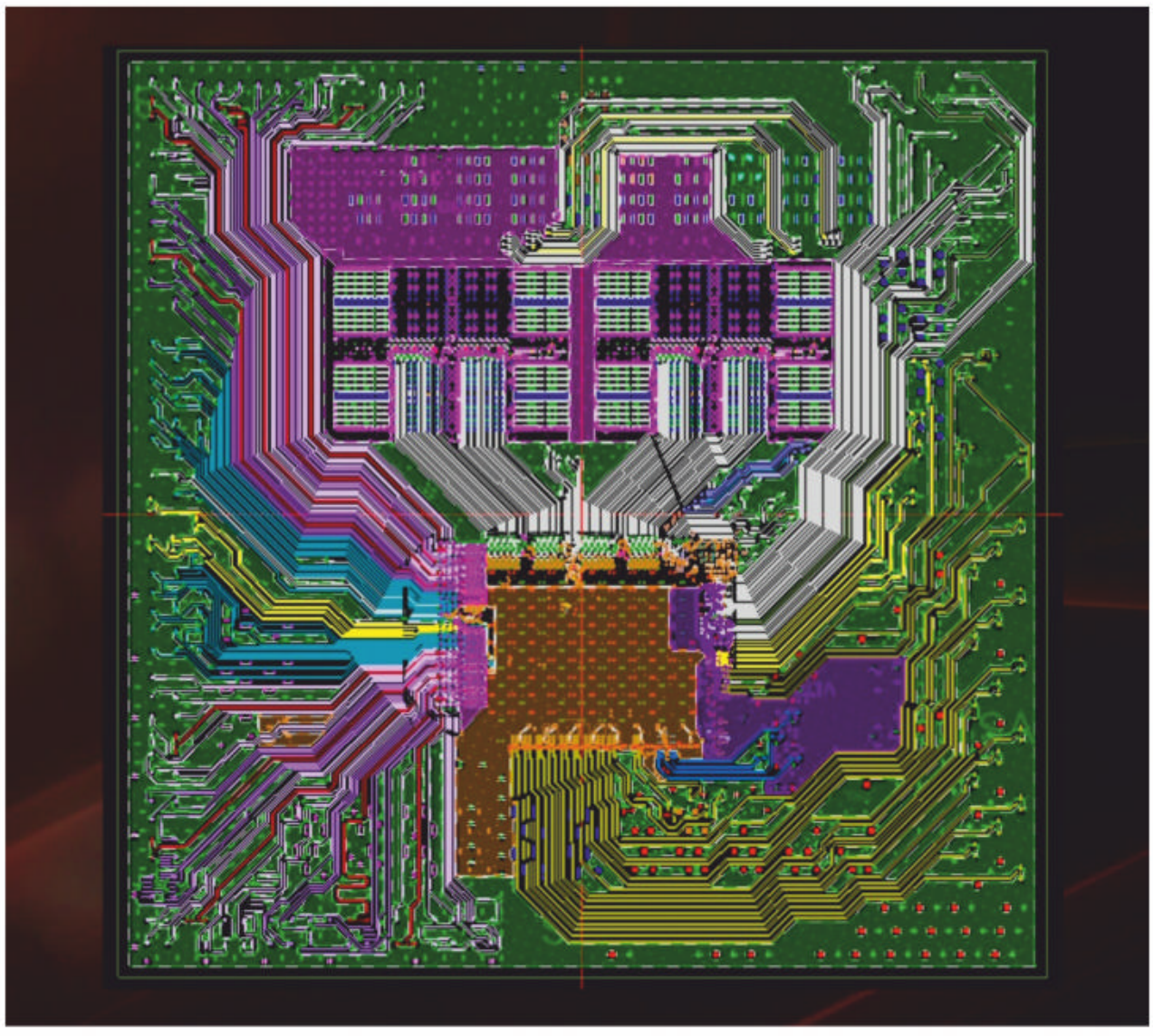
Intel goes the other way, artificially restricting support for otherwise compatible CPUs. Bear in mind that 6th Generation Skylake processors all the way to 10th Generation Comet Lake processors are all but the same apart from the core count and clock speeds. If AMD can change architecture, process node, and move from PCIe 3.0 to PCIe 4.0 all along with the fundamental switch to a chiplet design without breaking compatibility, then surely Intel could have done it too despite not changing any of those things. But Intel is not known for such altruism.

So, what should the manufacturers do? AMD's approach is laudable, but issues with non-tech-savvy customers and the asterisk next to forward and backward compatibility is too confusing to many buyers. Three generations of genuine socket forward and backwards compatibility is sufficient.

A different solution would be to create a third socket. In AMD's case you could have TR5 for Threadripper, AM5 for Ryzen and another socket for Athlon. High-end, mainstream, and budget with support for several years and appropriate hardware pairing. Sounds simple? That way, every AMx or LGAx CPU could really work in every motherboard. We'll see if there are lessons learned. ■

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

"Is AMD's approach of long term support with caveats the way to go? Or Intel's with its recent trend of a maximum of two generations?"



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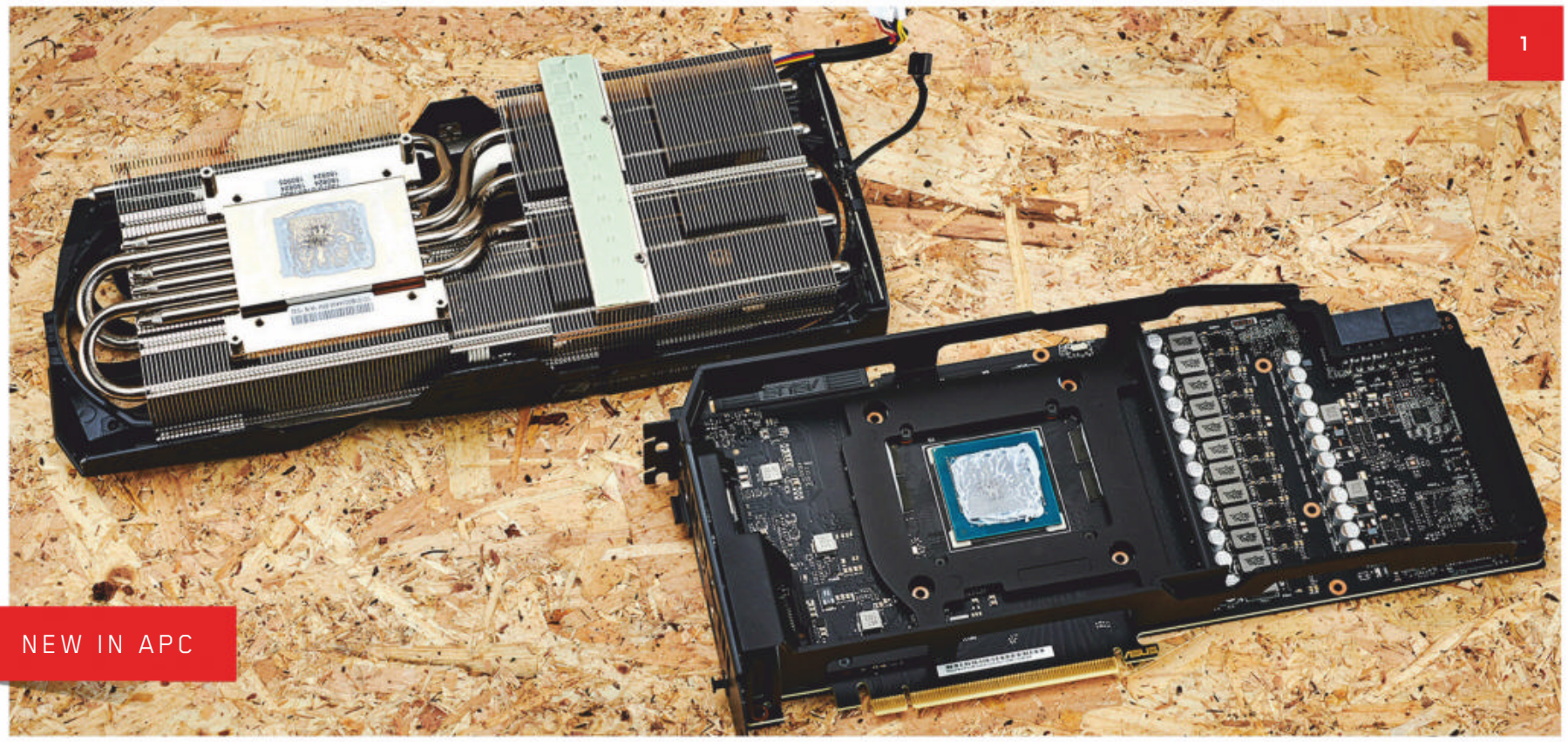

1

NEW IN APC

TECH TALK

Counterpoint: why liquid cooling is a horrible idea

Before you dive into our big liquid cooling feature this month, please allow us to talk you out of it – or, just maybe, get you even more excited.

Let's have a chat about that prodigal son of the custom PC world. Yes, I'm talking about liquid cooling. In particular, why it's not nice. I know that's going to sound ridiculous, especially given how in-depth our feature on it is in this very issue, but man is it frustrating at times.

Over the last five years, I've had the pleasure of building somewhere close to 60 separate PCs. 12 of those have come with varying forms of liquid cooling, not including AIO builds. So I've toyed with everything in this niche hobby of a hobby. Alas, this gives me some serious perspective as to why liquid-cooling sucks. So let's break it down.

01 The cost

First and foremost, the biggest hurdle any would-be liquid cooler has to get past is the expense. The problem is, if you're committed to your liquid-cooling aspirations (because let's face it, it looks cool, and for most of us that'll be 70 percent of the reason to do it), you're going to start by stripping down something like a $1,400 flagship graphics card, and strapping a $200 water block on.

02 The fittings

Oh boy, where do I even begin with this one? For any first-time liquid cooler, when it comes to these tiny, pricey parts, you'd plan your rig, go "OK, I'll use soft tubing first as that's the easiest," and then say to yourself, "All I need is some compression fittings to get the job done." Although technically this is possible, building a rig with just soft tubing and standard compression fittings is not the easiest way.

And here's the thing; the more liquid-cooled rigs you build, the more experience you gain, and the more likely you are to lean into using an ever-increasing arsenal of fittings. Which in turn jacks up the price.

To give you an example, the 4K gaming monster build we did back at the end of 2019 featured a total of 70 fittings, of 12 different types and two different brands, totalling well over $1,000. That is an insane figure, but couple that with the average water block costing well above the $200 mark, radiators being close to $100-$200 each, and pumps and reservoirs commanding equally as much, and you can easily end up with a loop cost bracing itself at near $2,500.

ZAK STOREY
Zak has been a PC enthusiast and system builder for nearly 2/3rds of his life.

03 The knowledge

And then we have the painful learning process involved with this whole thing, so much of which is trial and error, researching, and planning, and it's just endless. Here are some basic guidelines: First, always ensure that your pump is gravity-fed by a reservoir. Second, never mix your metals in a loop, and if you can afford it, always use copper. Third, when filling your loop, always ensure that all of your components remain unpowered, except your pump, and never let it run dry. Fourth, always try to flush your blocks and radiators before you build your loop to get rid of any excess flux. Fifth, always test that your components work before commencing your build. Sixth, always double-check you've either plugged or connected tubing to every available G1/4 port. Seventh, always triple-check that your compression fittings are tight enough on your tubes, and that your tubes are seated correctly. Eighth, never forget a rubber o-ring.

04 Bending tubes

After that's all out of the way, you've then got tube bending, which is a mystical art in itself,

and honestly I question how it works every single time I do it. And every time when I produce my first bend, I can guarantee you it still feels like I'm doing it for the very first time.

When it comes to tubing, you have to consider whether its PETG, or normal acrylic you're bending (PETG has a lower bending point and different heating characteristics, and is shatter resistant, but it's slightly less transparent and has a habit of color-leeching a little sooner). You then have to plan where the bend is going to be in the length of tubing, the angle you want to achieve, and what you're going to use as your angle guide. In all honesty, most folk, myself included, will recommend that you stick to lengths of tubing with a single 90-degree bend in it. Any more than that and the tubing run starts to look messy and nowhere near as sharp as how you pictured it in your head – at least until you're a pro.

That said, if you are after additional angles, there are a ton of good bending kits available (here's looking at you Alphacool). But honestly after a while you'll just end up using the corners of tables, or anything square. In my case, rather ironically, I use the corner of a bending kit pelican case to achieve my 90-degree angles, failing that you'll just end up eyeballing it.

That said, with all the best will in the world, you can watch numerous videos and tutorials on how to bend tubing, but the best way of learning how to do it is by doing it yourself.

05 The performance gains

This is going to hurt me to say this, but honestly, the performance gains are not as grand as we all like to think. Yes, you will get lower temperatures, but the majority of the time your components are just going to be limited by their architectures and your draw in the silicon lottery. If you're big into overclocking it certainly helps, but it's not enough to overcome major stability hurdles. In fact, at most you're going to be looking at perhaps a 10-15 percent performance increase versus traditional AIOs or air cooling, and that's being generous.

The biggest advantage is with auto-overclocking features such as that found on Ryzen, with Precision Boost Overdrive in particular (especially if the VRMs are cooled too), and with GPU Boost for graphics cards.

The best thing about liquid cooling is the reduction in overall noise that's achievable. Strap two massive 360mm radiators into a loop with a single GPU and CPU, and you can immediately run those six fans far quieter than if those components were cooled traditionally via attached air coolers and heatpipes.

06 The maintenance

So you've got your system up and running, it's fully liquid-cooled, looks baller, temperatures are lower and performance is slightly higher, now you've got to maintain it. In the first week that means your first challenge is going to be getting rid of any trapped air throughout the system. To do this, you can wait, or you can tilt and shift and shuffle the case around in what seems like the world's biggest puzzle, in an attempt to get the air bubbles up to the reservoir, before topping it off with a bit more coolant. Once that's done, congratulations! Your system is running as intended.

However, over time, without proper maintenance, coolant can gunk up water blocks and stop them from functioning as efficiently, reducing thermal performance in the process. That means every 6-12 months (sometimes longer if you've got the right coolant) you'll have to drain the entire thing, strip it all down, remove and flush the radiators and the waterblocks, put it back together again, and refill it.

07 The reality

So the reality is that it costs an absolute bomb per loop to create, takes an age to learn how to do properly, requires some serious thinking and planning before you even look at buying parts, and the performance gains outside of noise reduction are few and far between. Add in the additional anxiety that comes with stripping down stupidly expensive components (thanks Nvidia), building your own loop, and having to maintain it all, and it just really doesn't make any logical sense to the average user.

Yet here I am, 12 liquid-cooled systems in, still building them, still learning from every attempt, and it's likely I'll continue to do so unless I lose the passion for this woeful hobby of ours. Why? Well, aside from my delicate Millennial ears preferring my PC to make somewhat less noise than a jet engine at take-off, the reality is that builds like these just look so damn cool. They're a halo product among halo products, the true pinnacle of what you can achieve, and if you can look past the long list of frustrations, the eye-watering expenses, and the time it takes to create these short-lived performance kings, as our industry moves ever upwards in core count and clock speed, there's just something unequivocally beautiful about the results of probably one of the most frustrating hobbies that's in existence. ■

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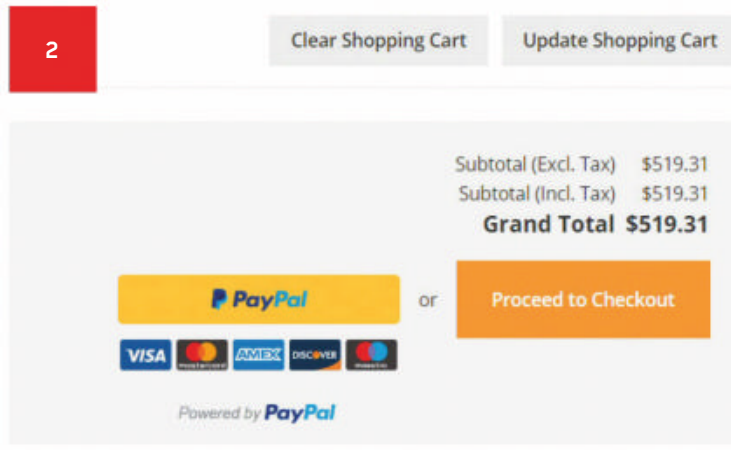

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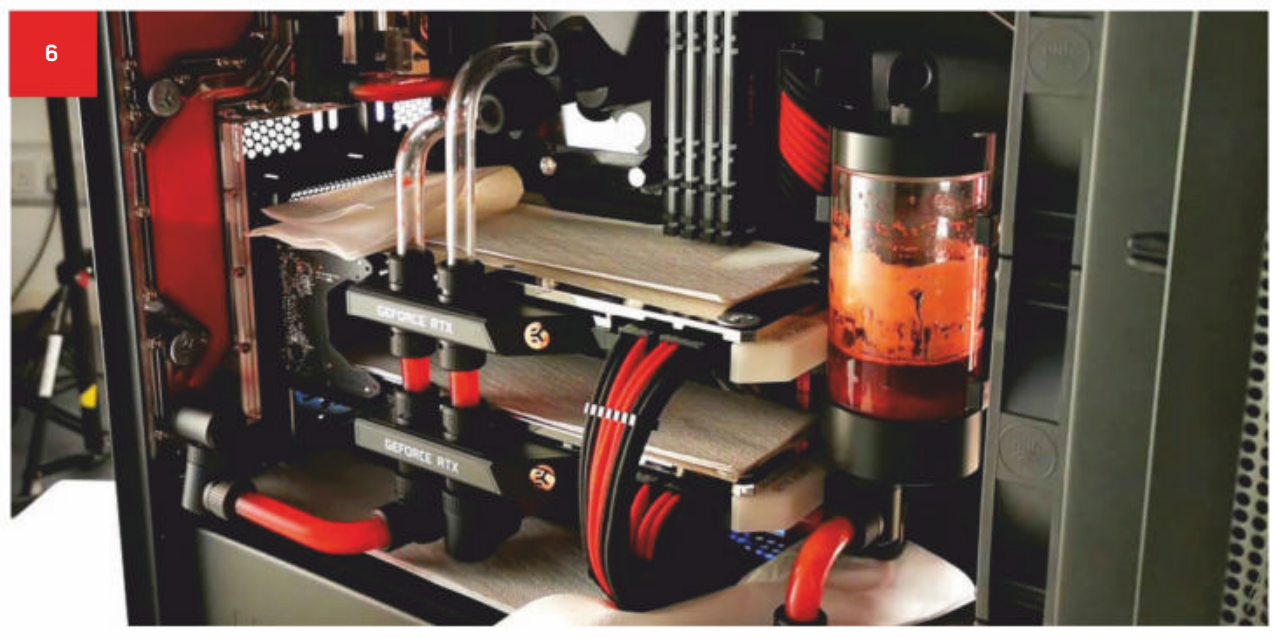


NEW IN APC

OPEN SOURCE

Are Docker containers a good idea for laptops?

Running an app in a Docker container isn't necessarily safer than running it on the host OS.

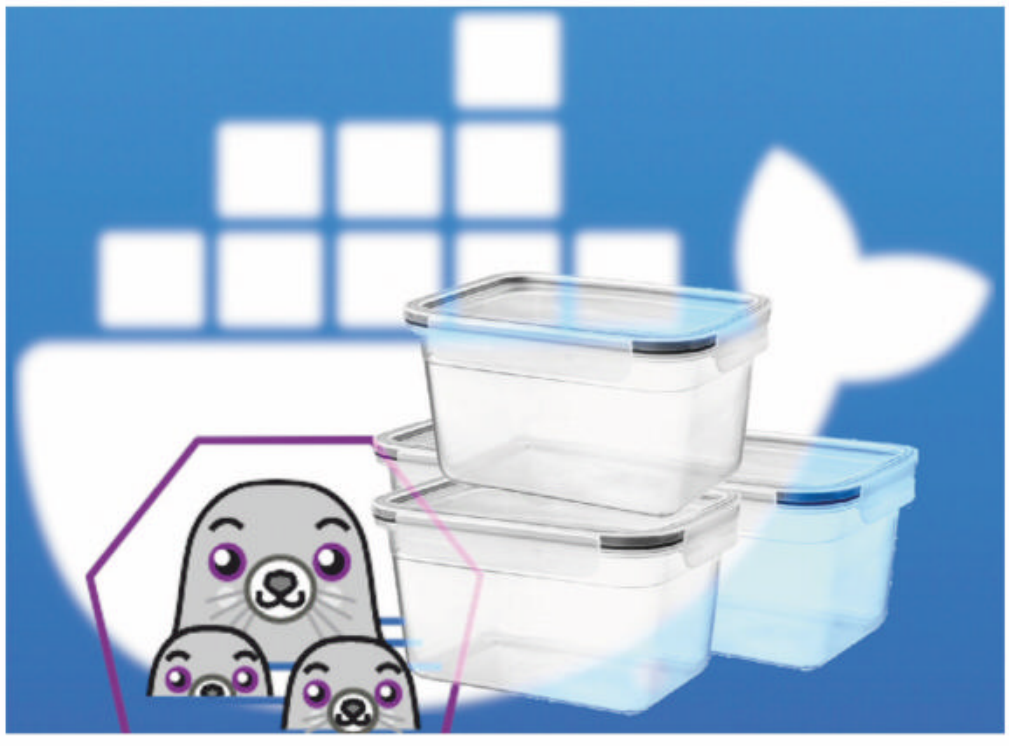
Docker containers are cool. If you haven't yet played with Docker, you're missing a large world of easily deployed applications. For example, I can deploy NodeRed, Plex, Jupyter Lab, and Nextcloud servers, and run them behind a Traefik reverse proxy with a single command and a YAML text file. If you're running an HTPC, NAS, or home Linux server, Docker lets you do just about anything.

Containers (like Docker containers) emulate a filesystem, networking, and other OS components in order to allow applications to isolate themselves from the host OS. Containers generally don't require dedicated resources, so they're often preferred to virtual machines for single applications.

Installing web apps such as Plex or Nextcloud directly on to your OS can be a pain, depending on the application stack. Windows-esque "DLL Hell" has its evil brother on Linux in the form of broken dependencies. If one program requires a different version of a library from another program, updating or installing those two programs together can be tricky, if not impossible. Containers fix this by packing up all the dependencies for a container's image (like a package) and running them in an isolated environment. If a web app requires a particular version of Python, using a Docker container prevents it from conflicting with the OS's version. Flatpak and Snap packages are containers in many ways, but the formats are largely geared toward desktop use. The Docker image paradigm is king when it comes to web and applications.

There is one glaring problem. The Docker daemon must run as root. So, anyone who can talk to Docker has root privileges. As a result, any container running on the system can potentially obtain root privileges on the host. The other problem is that Docker's networking stack can play hell with the Uncomplicated Firewall (ufw), a common default firewall for many Linux distros. Because the Docker daemon has root access, IPTables can happily overwrite ufw's rules without letting you know.

"The Docker daemon must run as root. So, anyone who can talk to Docker has root privileges. As a result, any container running on the system can potentially obtain root privileges on the host."



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

There is a better way if you're not looking to deploy a web service on a network. Podman aims to be close to a drop-in replacement for common Docker tasks. It can grab Docker images from online repos and deploy them with the same commands you'd use with Docker (but using "podman" instead of "docker"). Its sister app Buildah builds container images from Docker files, too.

Podman doesn't run as a daemon, so doesn't require root. This also means that containers started by non-root users can't get root privileges either. However, without the Docker daemon, there's no process to watch after Podman containers. This requires the user to run some other service (such as Systemd) to start and stop container instances. Podman refers to "pods" in the Kubernetes ("k8s") sense. A Kubernetes pod is made of one or more containers that are created and destroyed as one. (A "node" is a single virtual machine that hosts pods.) Podman is an alternative interface for launching pods on a Kubernetes cluster. The Kubernetes supervisor orchestrates node and pod deployment, so the Docker daemon isn't necessarily needed.

Feeling adventurous? Try the k3s project, which removes some overhead from Kubernetes. K3s is designed to run on embedded systems, but is a great way to learn Kubernetes on a local system, with no hefty setup or VM overhead. ■

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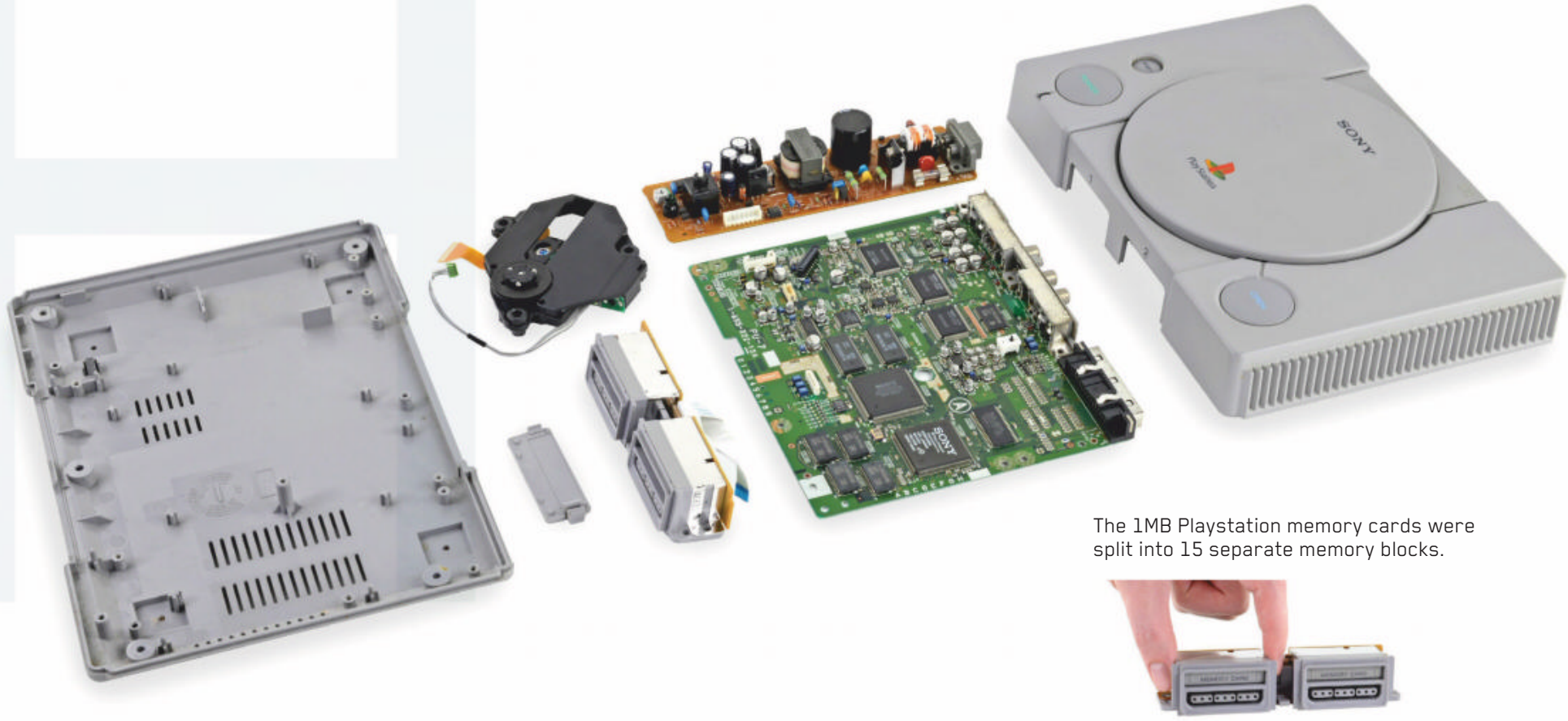
HOW IT'S DONE

TAKING THINGS APART AND HAVING A POKE AROUND



The 1MB Playstation memory cards were split into 15 separate memory blocks.

Sony Playstation

This month we're going retro...

Originally developed as part of a joint venture between Sony and Nintendo to make a CD-equipped SNES console, Playstation is now one of the world's most recognised brands. For its 25th anniversary, we got our hands on the unit that started it all, the Japan-only SCPH-1000 model. We're celebrating the only way we know – time to tear it down!

Major tech specs

- MIPS R3000 33.9 MHz, 32-bit RISC CPU
- 32-bit GPU
- 2MB RAM
- 1MB VRAM
- 16-bit 24-channel PCM stereo sound
- 2x CD-ROM Drive

Key findings

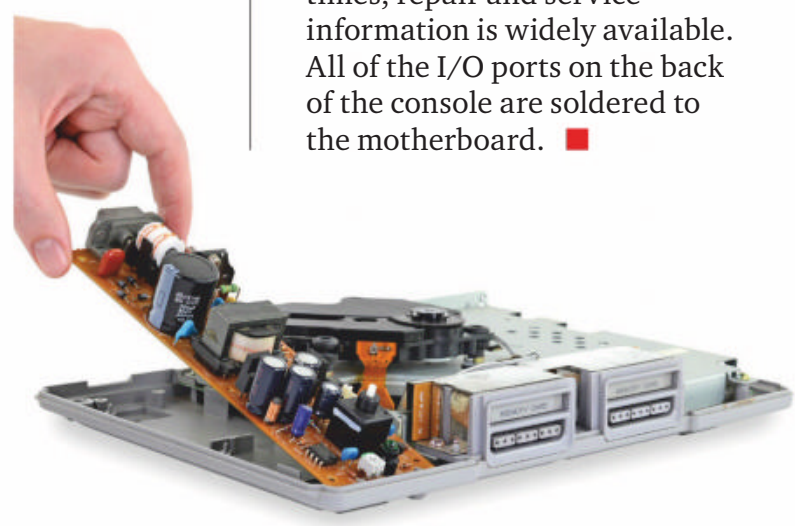
- The Playstation was only available in Japan during its first year on the market. The most noticeable cosmetic difference between the Japanese and global models is the Playstation logo on the lid. The Japanese model sports a bit of green instead of the Playstation blue, as well as a brownish color in the logo's negative space.
- So how do we get inside this thing? It turns out each screw holding the two halves of the console together is marked with a little arrow! These helpful pointers are a breath of fresh air. Actually the air is pretty dusty – this thing is old.
- We lift the lid off, hoping that gems will fly out for us to collect. We're left empty-handed in the gems department, but there's some pretty cool stuff here. First, let's carefully dispose of this power supply before we get zapped. This internal power supply takes up roughly 20 percent of the console's footprint. 90's silicon didn't run as hot as today's hardware, but it's still impressive to see an internal power supply, an optical drive assembly, and everything on the main board running in a fanless configuration.
- Next up, the controller ports and memory card slots come out as one assembly. The CD laser and motor assembly rests on three pegs, secured in place by rubber grommets. This allows the entire mechanism to move around slightly and absorb vibrations from the spinning disc. In case your mother never taught you:

Never touch the lens.

- With nowhere left to turn, we lift up the giant metal shield hiding the motherboard to reveal the main act. Like Lara Croft, we carefully lift this dusty relic from its home, hoping we haven't tripped a booby trap. To our relief, it appears we haven't sprung any. We've struck gold here – this thing has more chips than three bags of Tostitos… and flipping the motherboard over reveals a few more.
- And that's it! There's not much inside this Playstation, which is a testament to Sony's design and engineering chops – or maybe technology was just simpler back then…
- Repairability 8 out of 10 (10 is easiest to repair). The console is made up of few components, and each one is straightforward to remove and replace. Only a Phillips screwdriver and a spudger are needed for complete disassembly. The optical drive is one of the easiest components to remove. Since the Playstation has been around the block a few times, repair and service information is widely available. All of the I/O ports on the back of the console are soldered to the motherboard. ■

This Playstation is commonly referred to as the "PSX" because "Playstation X" was its codename during development. The name stuck even after the X was officially dropped.

Despite the Playstation's small size, Sony was able to cram this PSU in here without breaking a sweat.



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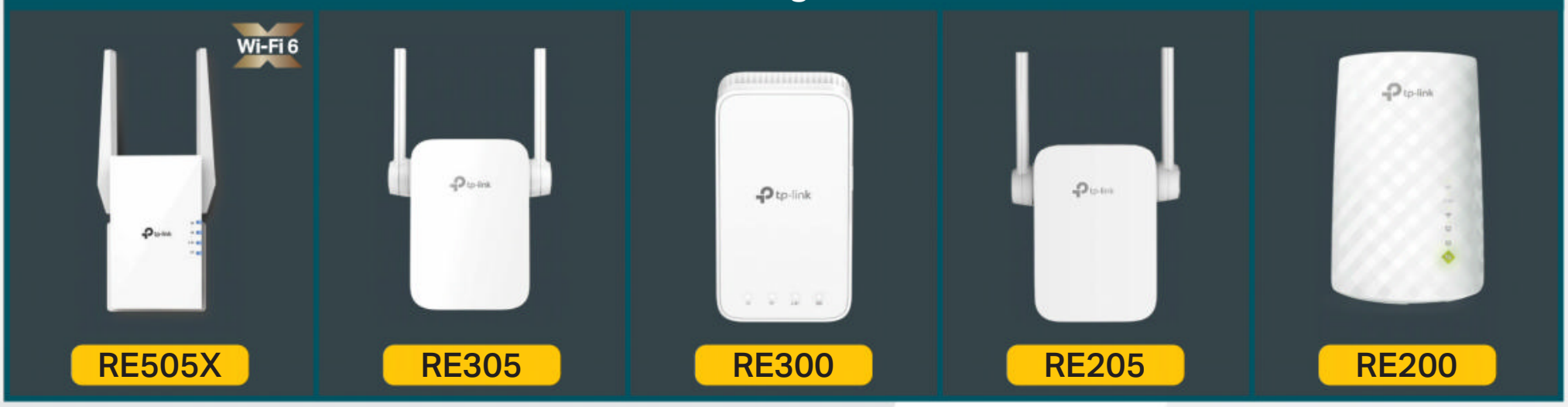

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THE LIST

Indie games you should be playing

08

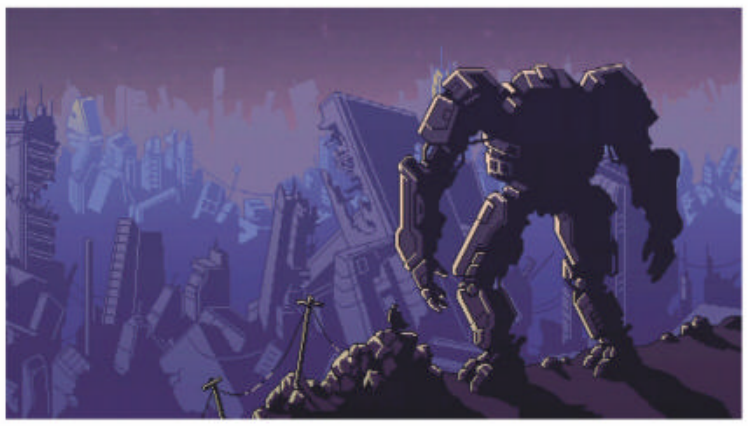
Tacoma

An abandoned spaceship and a rogue AI are the backdrop for a gripping puzzle game, where you manipulate 3D security footage to glean information from your surroundings.

06

Deep Sky Derelicts

A bleak dungeon crawl through the empty husks of ancient spaceships.



04

Into The Breach

Sadly underappreciated, despite its blend of sci-fi puzzling and turn-based strategy.

02

Griftlands

This is a sci-fi roguelike with deck-building and narrative decision-making elements.

07

What the Golf?

It's golf, but not as you know it. Launch everything from houses to hot dogs with your trusty 9 iron in this surreal and hilarious sports sim.

05

Ape Out

Take control of a painted gorilla and bust out of zoos, prisons and research labs, all to pumping jazz.

03

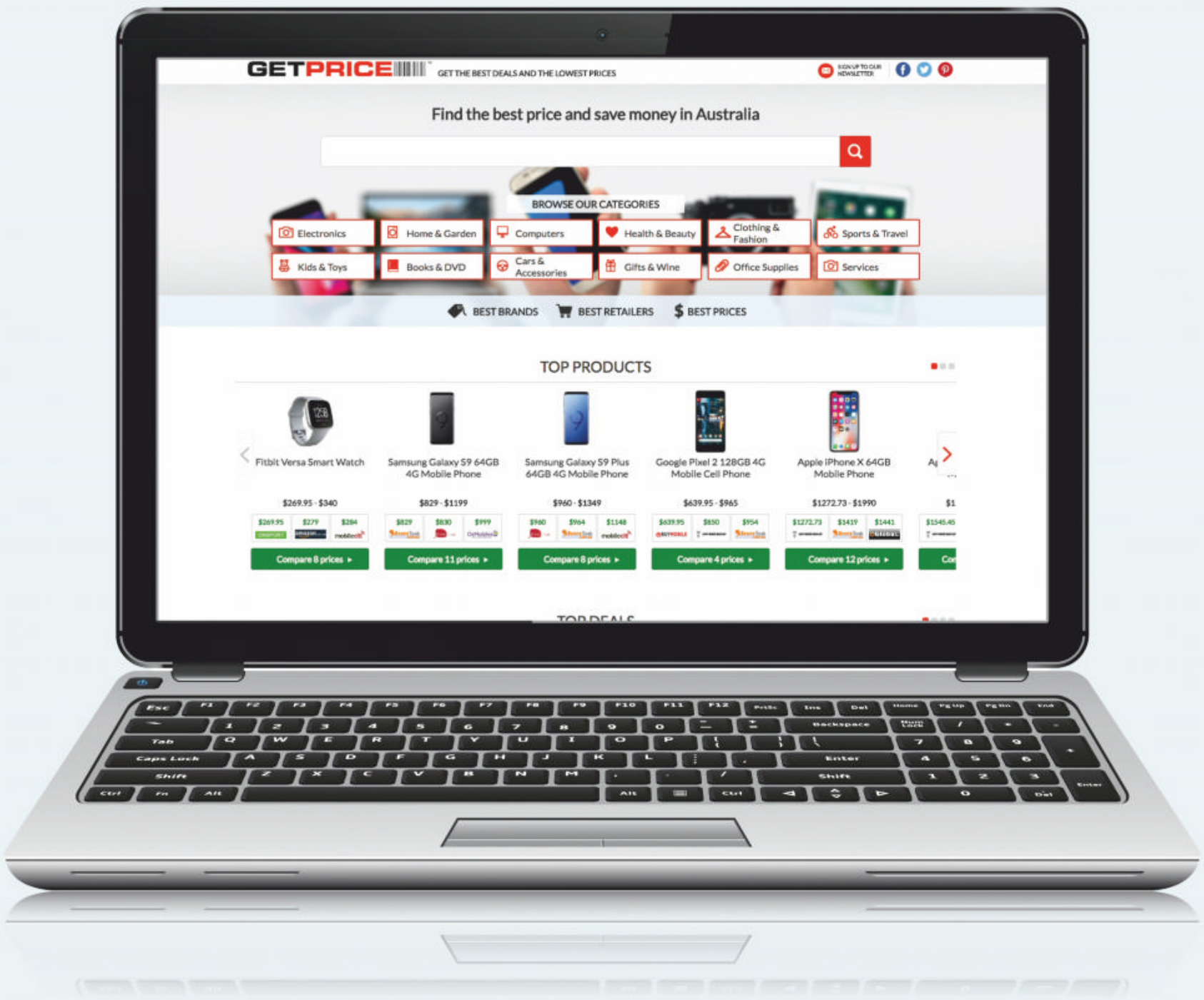
Jøtun

Gorgeous hand-drawn boss fights punctuate this jaunt through Scandinavian mythology, as you play a betrayed Viking warrior fighting to prove her worth to the gods.

01

Furi

A frenetic boss rush, swapping between close-quarters combat and chaotic bullet-hell sequences. ■



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HyperX Ducky One 2 Mini

Maximum minimalism.

You may be surprised to learn that 60%-size mechanical keyboards are a huge cult hit. Fans proudly show off their creations made with custom keycaps and chassis', and the biggest supplier of components is Taiwanese company Ducky. Now, the company has teamed with HyperX to produce this, and it's quite lovely. The black keys are offset by red esc and return keys; it's a conservative styling, but it does look fantastic, and because this is HyperX it also has an RGB ring around the egde if you want more... presence. Being 60%, you don't get a numpad. Nor dedicated arrow keys – though you can still point using a fn combo. The key mechanism is HyperX's own, and they feel most like soft Cherry Red switches. This is exclusive to PCCG.

$119.95, gopro.com/en/au

GoPro Zeus Mini

Light it up wherever you are.

GoPro's Mod debuted a LED lighting module that carried its own charge and attached to the camera to keep things well lit while on the go. It seems GoPro didn't realise just how popular a wearable six-hour, 200 max lumen LED light was, because it's now re-engineered this module to work as a standalone unit straight out of the box. You can still use GoPro's existing range of mounts, but the Zeus Mini comes with a two-axis (swivel, pitch) mount and a magnetic clip to provide more maneuverability and quick attachments to a wide range of surfaces. It's also waterproof to 10 meters and lights at a cool 5700K colour temperature (perfect for Hero shots).

$499, en-au.sennheiser.com

Sennheiser Momentum True Wireless 2

Everything we loved about the first, and now smaller.

Out of the box, the keen-eyed will immediatly notice the Momentum True Wireless 2 are 2mm smaller than the previous version. No? Me either. What will be noticable is how bloody comfortable (and gravity-defying) they are in the ears and how gorgeous they sound. The 7mm drivers are more than capable and made short work of our go-to headphone-test playlist (an eclectic mix of Bieber, Gotye, Lorde, Run the Jewels and Slayer) without skipping a beat. Improved playback battery – up to 7 hours – and Active Noise Cancelling and are both welcome additions to an already feature-rich offering, the latter more-so once **we're back** to the full-time commute grind after isolation. A little quiet on the way to the office is worth that eye-watering price.

From $5,500, specialized.com/au/en

Specialized Turbo Vado SI

A flyweight eBike for commuters that can live with less assistance.

Weighing in at just 14.9kg, Specialized's new Turbo Vado SL has been designed to be only a little heavier than a regular bike and 40% lighter than your average e-bike. Battery capacity is generally the first thing to go when you're trying to cut weight, but the 320Wh internal Turbo Vado SL battery offers 130km of assisted riding with the option to add a range extender for another 64km. You will have to be willing to do a little more of the work yourself since the motor only offers two times the pedal power, but it's not a bad compromise to get an ebike that looks like a regular bike.

$195, nixsensor.com

Nix Mini Colour Sensor

The Shazam of colour matching.

Shazam was one of those pieces of software that everyone imagined before we had the technical capabilities to make it a reality, but for stylists and designers, colour hasn't had this kind of quick fix solution… at least until now. The Nix Mini Colour sensor is a pocket-sized scanner that samples any real world colour you hold it against and connects to a smartphone app via Bluetooth to digitally catalogue it and identify the brand and name of the paint colour if possible. In Australia the device has all the biggest paint manufacturers' catalogues, but if you want to go off-piste you can digitally record any colour you want, be it flowers, rocks, or artworks.

$79 (MB), $59 (VGA), xpg.com

Adata XPG Prime ARGB cables

Cables of glory.

As you stare at your fully RGB PC, bathing in its rainbow splendour, you are thinking 'why can't the cables be RGB, too?' We hear you. And so did Adata. Running outside the regular data cables are optic fibres that do the usual RGB business of glowing and pulsing across many different effects. They're supported by all the common RGB apps, but better yet – there's a little button box for selecting colours and modes so you have one less thing to add to your RGB software. Adata has a cable kit for the main 24-pin motherboard cable, and another for your 8-pin VGA power ports.

Full-tower cases can get pretty weighty, like the 30kg Obsidian 1000D from Corsair.

HEAD TO HEAD

Mini cases vs mid cases vs full-tower cases

We compare the the most popular case sizes to help you choose well.

Case size – it's an interesting question. Should you go for a mini tower, with its ITX motherboard and compact design? Or the full tower, with room for numerous components and cooling solutions, ideal for a super-powerful build? Or is the best option the humble mid tower case; the modern standard? We're going to break down the advantages and disadvantages of each type of case, and – hopefully! – decide which size is best.

Value

You might assume, if you're not well-versed in the pricing of PC cases, that mini tower cases would be the cheapest option. That's not always the case, though, as compact chassis tend to have additional design aspects that make for more efficient use of space, and these drive the price up. Fractal Design's Node 202 media center case includes a right-angled PCIe riser for vertical GPU mounting – it's necessary in such a flat case but is also an extra item to add to the price. That said, it's also easy to find mid-tower cases with pricey add-ons.

Full-tower chassis, unsurpsingly, are the most expensive. We went hunting for the cheapest case of each type that we would actually recommend (no super-cheap knock-off brands here) and while good mini and mid-tower cases both went as low as the $90 mark, we'd have to spend almost $180 to get a decent full-tower chassis.

Most of the big names in cases – Corsair, Fractal Design, Cooler Master to name a few – have a wide range of cases available, large to small, pricey to affordable. The usual missing combination here is budget full-tower cases; typically, if you've got the cash for a big, powerful system build, you can afford to splash out on your case.

Winner: Mid Tower

Slender mini-tower cases can make for excellent home media centers.

Flexibility

This was an interesting category to interpret. Should we award it to full-tower cases, with their ability to fit any size of motherboard and cooler? Or does the prize go to mid towers, the middle-of-the-road choice, the jack-of-all-trades? Let us explain our logic.

For flexibility, we considered what different roles a system built inside each case could fulfill. As such, we eliminated full towers from this round, on the basis that a full-tower PC can only really function as a big, powerful desktop system; perhaps a dual-motherboard rendering or streaming rig. Using a full tower as a home NAS system is farcical, unless your family somehow has enough data to fill 20 hard drives.

A mid tower can be more or less anything; gaming PC, editing machine, media center. However, the win goes to mini towers. Anything a mid tower can do, a mini tower can do – only in a

smaller and more portable way. A compact form is a very desirable feature for media center and home-cloud servers, able to unobtrusively occupy space under the TV or in the cupboard. Advancements in modern CPUs and GPUs mean that tiny systems can be rendering powerhouses now too, perfectly capable of keeping up with their mid-tower cousins.

Winner: Mini Tower

Build Difficulty

Ask any member of the *APC* crew about the worst case they've ever built in; chances are, the culprit will be a mini-ITX offering. Limited space to work in, component incompatibility thanks to inadequate headroom, and arcane cable-routing solutions often lead to frustration when building inside a mini tower. While they are at least usually lightweight and easy to move around while building, the cramped interiors mean that the builds prove much trickier than expected.

Full-tower cases, of course, have the exact opposite problem. You'll always have enough room to get both hands (and in some cases, both forearms) inside the case to work, but the bulkier form factor means that moving the case around during builds is a hassle. Full-tower cases routinely weigh upwards of 30 pounds, too,

What brings us a sigh of relief is seeing a Build It plan that uses a mid-tower case. The mid tower would never slice open our fingers as we struggled to squeeze a screwdriver inside it. The mid tower would never slip out of our hands and land directly on our big toe. The mid tower is safe; it's familiar, even comforting. And thus, we have our winner here.

Winner: Mid Tower

Features

As we mentioned earlier, mini-tower cases have plenty of potential for nifty additions. We've seen everything from giant solo fans to removable I/Os, and yet the teeny-tiny cases are still the ones that manage to innovate. Yes, a full tower can fit 10 RGB case fans at the front, but most systems don't need that; space-saving solutions for a powerful but compact system are far more valuable.

Larger cases do tend to have larger I/Os with more ports, but again it becomes a point of quantity over innovation; four USB ports on the front of your system is nice, but is that better than two USB-Cs? And, do you really need a front I/O with four USB-A ports?

Really, any case can have cool and useful features beyond the baseline, most of which will usually make the case more expensive. If you browse for cases upwards of $150, chances are it'll have some fancy unique selling point to persuade you to buy it. One of these pops up more often than others, though; various iterations of the carry handle, sometimes seen atop mini-tower cases. A handle might seem simplistic, but it's a feature that can totally change a system's purpose, instantly making it easily portable, and for that reason we'll give the win to mini towers.

Winner: Mini Tower

Aesthetics

Again, this is a tricky one to judge, mainly because the question of aesthetics often comes down to a subjective opinion rather than objective fact. Even in the *APC* office, debates as to whether a new case is ugly or beautiful are as frequent as they are fierce. What constitutes a good-looking case? Some would argue that it's a full cohort of synchronised RGB lighting, while others might say that sharp, defined angles and colors make for the best visual design.

Whatever your opinion, we think it's fair to say that mini towers might lose out this round. It's still a matter of personal preference – we're sure many of our readers (and this mag's Editor) love the look of mini-ITX cases – but the compact design simply means that there's less space for the manufacturers to show off their aesthetic chops. Many small cases opt for a simplistic design, to favor portability or to better blend into a room.

In fact, upon browsing through some online storefronts, the majority of mini-ITX cases are just nondescript metal boxes, with only a handful even offering something as basic as a windowed side panel. Both mid and full-tower cases often feature tempered glass windows to show off the inside of the build, so we're going to declare this round a tie.

"We've seen everything from giant solo fans to removable I/Os, and yet the teeny-tiny cases are still the ones that manage to innovate."

Mid tower can still look super slick, as Phanteks proves with this model.

Winner: Mid & Full Tower

And the winner is...

Yes, the best kind of computer case is the mid tower! Really, if you're building a desktop system for regular work or gaming, the mid tower is frequently the best option. It's the working man's case; adaptable, affordable, and typically straightforward to build in. They're the perfect cases for inexperienced system builders, too; if you're new to the game, or want to help a friend assemble their first PC, mid tower is the way to go.

With that in mind, though, it's important not to underestimate the worth of mini and full-tower cases. Ultimately, the best case for the job is the one that best suits the purpose of your builds; if you want a dinky LAN gaming system to take to your buddy's house, you'd best find yourself a mini-tower case with a carry handle. Conversely, if you're committing to streaming and want a dual-system setup, a beefy full tower like Corsair's Obsidian 1000D will suit you best.

The best type of case is simply your favorite type of case. No matter what size or what you use it for, as long as you like your case then it's a good case (mid towers still win, though). ■


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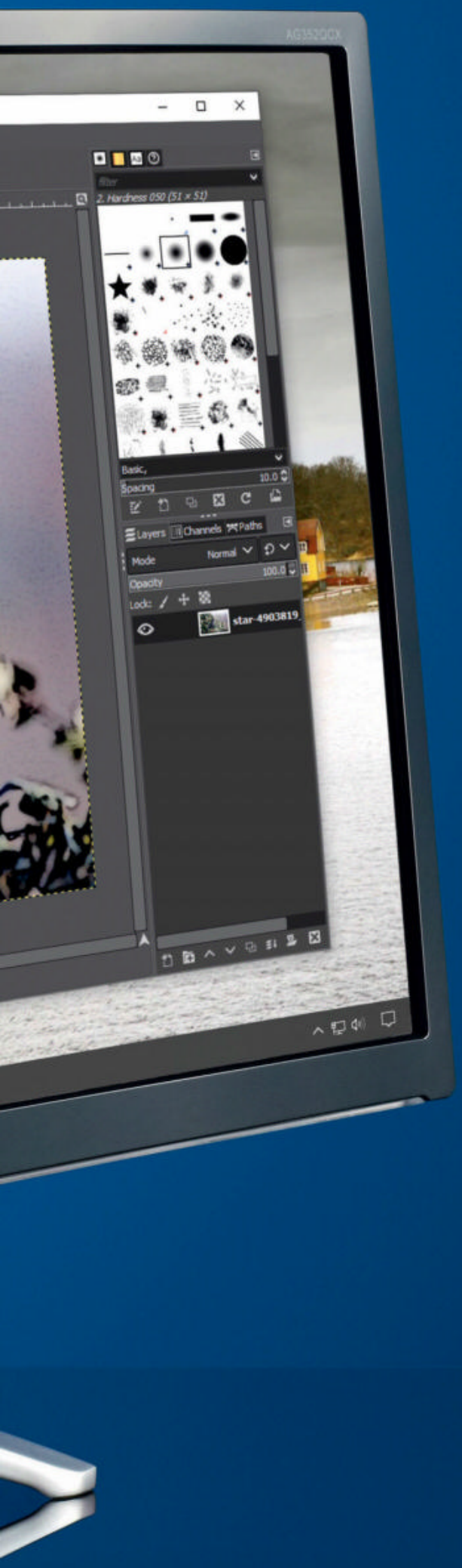


FEATURE

THE BEST FREE SOFTWARE OF 2020

ALEX COX COMPILES SEVENTY COMPLETELY FREE APPS TO MAKE YOU MORE (OR LESS) EFFICIENT.

We know what you're thinking: Nobody actually wants a PC full to the brim with software. A guide to free software is one of those PC magazine tropes, and here's *APC* reaching into the well again. But wait, reader. Cool your jets and think about it. If you're looking at this guide and presuming that we're saying you have to install every little thing we've mentioned, you're doing it wrong.

This isn't about what you should have, it's about what you could have – software that could change the way you create, the way you work, and the way you manage your PC. It's about doing things better without breaking the bank. It's about software that actually deserves a place on your SSD, stuff that's so useful and well constructed that it's transcended the stigma that comes with the word "free."

The world of free software has changed significantly, because what we expect from software has changed. We have phones to thank for a lot of this – app stores have made free the default. The ever-increasing power and prominence of the web browser is another gift, because perfectly capable tools can be cooked up from JavaScript and HTML5. And the open-source community goes from strength to strength, with publishing, programming, and collaborative tools improving daily.

That said, there are some things we've sidestepped. Some software should be paid for, or it's made irrelevant by core Windows features. Antivirus is a strong example – either you rely on Windows' own tool, which is (or at least, has become) very credible indeed, or you stump up for a full version of a proper package, with the up-to-the-minute updates that come with it. A free VPN is a great idea until you realise that if you're routing your traffic through someone's servers and not paying them a single cent, they might have something else to gain from the whole thing. That's right, we're as cynical as you. But, darn it, we just love free software.

PC testing and performance

01 CPU-Z

Something everyone who's even tangentially interested in their PC's internals should have, CPU-Z pulls in the tiny details about your CPU, chipset, memory, and mainboard that Windows doesn't feel like sharing with you, and puts them all in one handy place. It can make a precise reading of your current clock speed for both CPU and RAM, too – great for overclockers. **www.cpuid.com**

02 GPU-Z

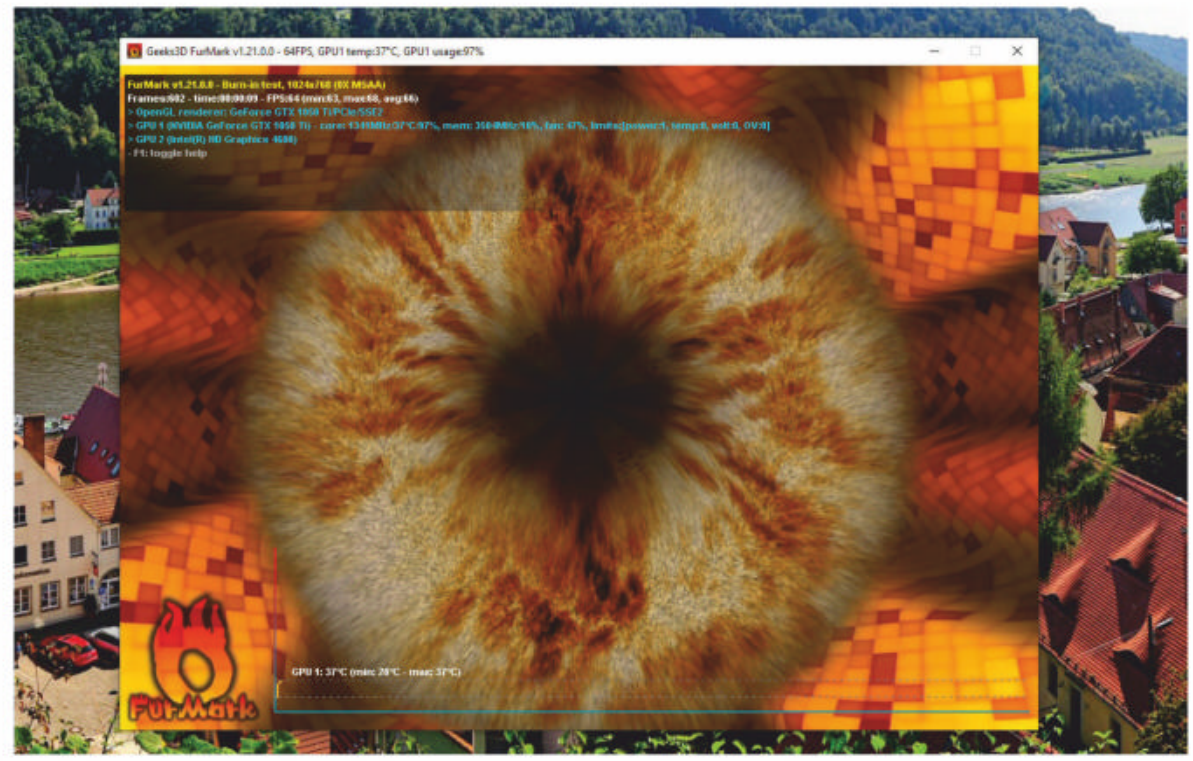
Despite the name, appearance, and incredibly similar functionality, GPU-Z has nothing to do with CPU-Z – but it does have permission from the CPU-Z author to use its title, which is nice. It's a GPU monitor, which can offer insights into both what you're running and just how well it's running, with access to a whole bunch of your graphics module's on-board sensors. **http://techpowerup.com/gpuz**

03 HWiNFO64

Where CPU-Z and GPU-Z are specialised snipers, HWiNFO64 is the buckshot-loaded blunderbuss of hardware monitoring. If there's a statistic out there you want to discover, it'll find it – and it's fantastic for overall system monitoring, too, with customisable graphs enabling you to track just about any metric or sensor output. **http://hwinfo.com**

04 Rainmeter

An odd choice for the system testing section? Perhaps. But Rainmeter sneaks in because, in the course of making your desktop look incredible, you can install a plugin like CoreTemp to hook your pretty desktop graphics into the heat of your CPU, or use a skin such as sysDash to display a host of customisable stats about your system. **http://rainmeter.net**



Be careful with FurMark– it's a really demanding and possibly damaging GPU stress test.

05 CrystalDiskInfo

There are, for some unknown reason, three versions of this disk status monitor, but the only reason to grab the Shizuku or Kurei Kei editions are if you're desperate to have a cute manga girl next to your impossibly detailed drive statistics. See also CrystalDiskMark, which will thoroughly kick your SSD in the teeth and see what it has to say about it.
http://crystalmark.info

06 FurMark

A GPU benchmark that earns its place here by virtue of its stress testing and burn-in capabilities. It will absolutely hammer your GPU with its OpenGL routine, so much so that the gallery on the official website proudly includes images of hardware that went bang when it couldn't keep up. There's also an Asus ROG edition available, which tests Vulkan, too.
http://geeks3d.com/furmark

07 Prime95

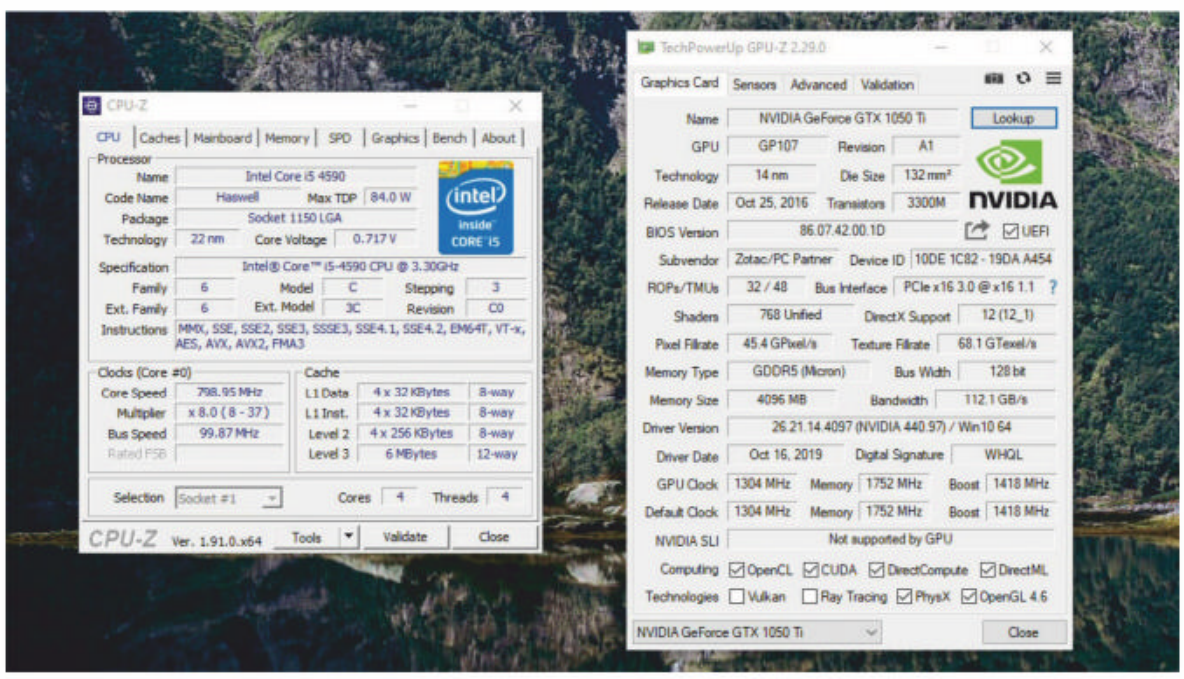
FurMark burns in your GPU, but Prime95 is a real CPU cooker. It hunts through a bunch of possibilities to attempt to find new Mersenne prime numbers – something it's managed 16 times since 1996. It's a computationally intensive task like no other, and its torture test mode can help you diagnose issues with your processor, chipset, cache, and much more. **http://mersenne.org**

08 Cinebench

Cinebench's visual benchmarking results make it a great tool for testing or racing one machine against another – but it's the built-in leaderboards that'll really let you know when something's up. If you're lagging behind a Core 2 Duo, either they've got some serious overclocking abilities, or there's a bottleneck on your end. **http://maxon.net**

09 MemTest86

A very old-school tool with an old-school approach, dragged into the 21st century by its USB boot capabilities and support for just about every memory type you could throw at it. Whether you're burning in your RAM or searching it for errors, there's something in its test suite for you – and it doesn't even require an installed OS. **http://memtest86.com**



Brothers from a different mother, CPU-Z and GPU-Z check what you have and how it's running.

10 OCCT
Comprising a massive suite of tests, from a FurMark-esque GPU smasher to a GPU-centric memory test to a version of the LinPack benchmark used to rank supercomputers, OCCT could be the only testing app you need. Its best feature might be its PSU test, which runs CPU and GPU benchmarks simultaneously to help you determine whether there's a lack of power anywhere in your system. **http://ocbase.com**

Desktop extras

16 Greenshot
Windows' screenshot abilities are getting better as time goes on (whatever you might think about Snip & Sketch) but there's nothing more convenient than Greenshot. If you're forever having to crop those dual-monitor screenshots down to size, or you're sick of launching yet another tool to get the job done, Greenshot's quick and easy system integration is a boon. **http://getgreenshot.org**

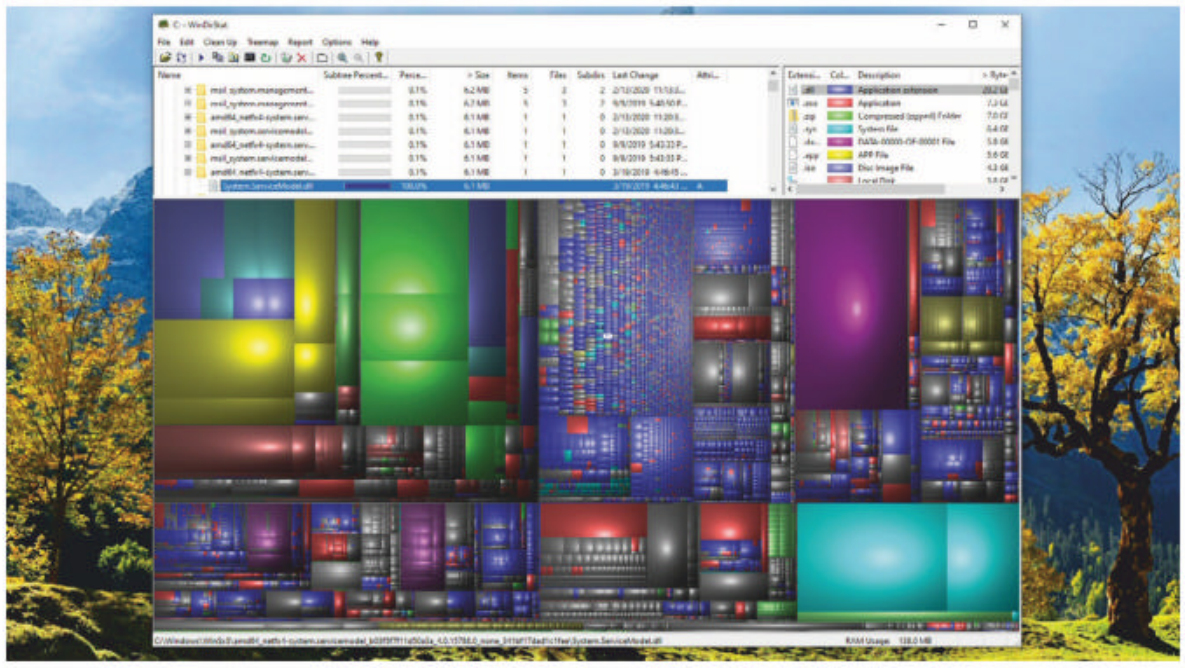
17 EaseUS Todo Backup Free
Some might be suspicious about the Chinese origin of EaseUS Todo Backup, but there's no better desktop backup tool out there, at least at this level of usability and simplicity. Regular backups, complete drive clones, scheduled copies, partition shenanigans, whatever you need – it's all a few clicks away, and restoring is just as straightforward. **http://easeus.com**

18 Fences 1.01
Later versions of Stardock's Fences have moved to a paid-for model, yet the lighter-in-features but nonetheless great version 1.01 remains free. It enables you to group together your desktop icons into fenced-off areas that stop them wandering around and interfering with others – you can group your games, your work apps, and so forth, for a truly tidy desktop. **http://stardock.com**

19 Total Commander
File Explorer is what we're used to, but it's a pretty awful way to manage the contents of your hard drive. Once you've switched to a hardcore tool like Total Commander, you might never go back. Its dual-pane system harkens back to the early days of file management (indeed, it's a modern clone of the Norton Commander formula) for maximum efficiency. **http://ghisler.com**

20 WinDirStat
Let's continue sniffing at things File Explorer doesn't do well – it's really difficult to find those files on your drive that are hogging space. Particularly useful (obviously) on those machines with limited disks, WinDirStat gives you a visual look at all your files, so you can immediately pinpoint the big boys and excise them then and there. **http://windirstat.net**

21 TidyTabs
Microsoft's long-mooted Sets feature, which groups your windows into tabbed collections, appears to have entered the testing trashcan. No problem: The execution might be a little clunky, but TidyTabs pulls off the same trick. You can mash together a File Explorer window, Microsoft Word, your web browser, whatever, all in one draggable, resizable unit. **http://nurgo-software.com**



Storage laid bare, reduced to colored rectangles with WinDirStat. Get rid of the big ones.

Improve your coding

11 Unreal Engine
There's a host of game engines out there for free (Unity and Amazon's Lumberyard primary among the rivals) but Unreal Engine tops our list this time. OK, it's not technically free – you have to pay a royalty if you're using it commercially – but being able to freely get your hands on the same engine used in AAA titles is great. **http://unrealengine.com**

12 Trenchbroom 2
This editor, which turns level editing for the likes of *Quake*, *Hexen 2*, and, er, *Daikatana* into a snap-together breeze, might be of niche appeal, but we love it. Besides, if you build your game to accept BSP files and use its "generic" template, there's no reason you can't use it – it's the official editor for old-school modern shooter *Dusk*, after all. **http://kristianduske.com/trenchbroom**

13 Visual Studio Community
Whatever you're coding, you need a good IDE. Visual Studio Community, which is free for up to five users in an organization, is a very good IDE indeed. It's modular, so you only install support for those languages you're working with, it's cloud-connected for collaboration, and (as you might expect) it's fully integrated with Git, too. **http://visualstudio.microsoft.com**

14 Python
If you're at the beginning of your code journey, Python is the language to start with. It's simple, friendly with its syntax, and capable of some solid results, with a wide range of libraries available to help you on your way. Download one of the Windows packages – being aware that Python 2 is just as well supported as Python 3 – and you get an IDE, too. **http://python.org**

15 Atom
A text editor geared toward coders, Atom (made by the GitHub team) is the lightweight alternative to a full IDE, for when you just want to tinker and tweak. Naturally, it has Git integration, it's highly customisable, and if you only want to use this to type up text documents, we promise we won't tell anyone your dirty secret. **http://atom.io**

Play some games

26 *Fortnite Battle Royale*

You've already decided whether *Fortnite* is for you, and we won't try to change that, but we will say this: It's entirely free to play, and the only detriment to not paying for its optional cosmetics is the likelihood of being called a scrub by a nine-year-old with a vocabulary made up entirely of a surprising number of vile slurs. **http://epicgames.com**

27 *Magic The Gathering: Arena*

Call us disingenuous all you like, because *MTG* is, like *Hearthstone*, a game you need to invest in to do well. But this client easily replaces the awful *Magic Online* as our favorite way to smash monsters together. Find a friend, grab one of the prebuilt freebie decks, and show them who's the spiciest planeswalker. **http://magic.wizards.com**

28 *Dwarf Fortress*

Rimworld may have taken the formula and run with it, but you can't beat the insanity of an intricately detailed dwarven settlement, with all the foibles of the dwarves within. Will they get offended by a horrible miasma, throw themselves off a ledge in a fit of madness, hide themselves away to create a masterwork when they should be chopping trees, or something crazier? **http://bay12games.com**

29 *Gwent*

Arguably the best thing about Geralt's sword-swinging adventures through *The Witcher III* was sitting down with random folk for a good old game of *Gwent* – and the spin-off game, which puts you in the Butcher of Blaviken's ample shoes, is just as rewarding. It's spawned its own esports scene, and is astonishingly moreish. **http://playgwent.com**

30 *Path of Exile*

The leading multiplayer *Diablo*-like (Diablike?) out there today, *PoE* is perfectly ransackable without forcing you to pay for trinkets and armors, and it's constantly growing with new expansions and upgrades. Beware, though: This game will get under your skin and stay there, and many people take it very seriously indeed. **http://pathofexile.com**

Click until you can click no more. *Path of Exile* is a compelling game.

22 Ninite

Setting up a new PC with apps is a tedious and click-heavy process unless you take advantage of something like Ninite, which pulls down your choice of programs and installs them fuss-free. That's only one of its primary functions; once you've done your multiple installation, you can run it again to update those apps seamlessly from one place. **http://ninite.com**

23 Wushowhide

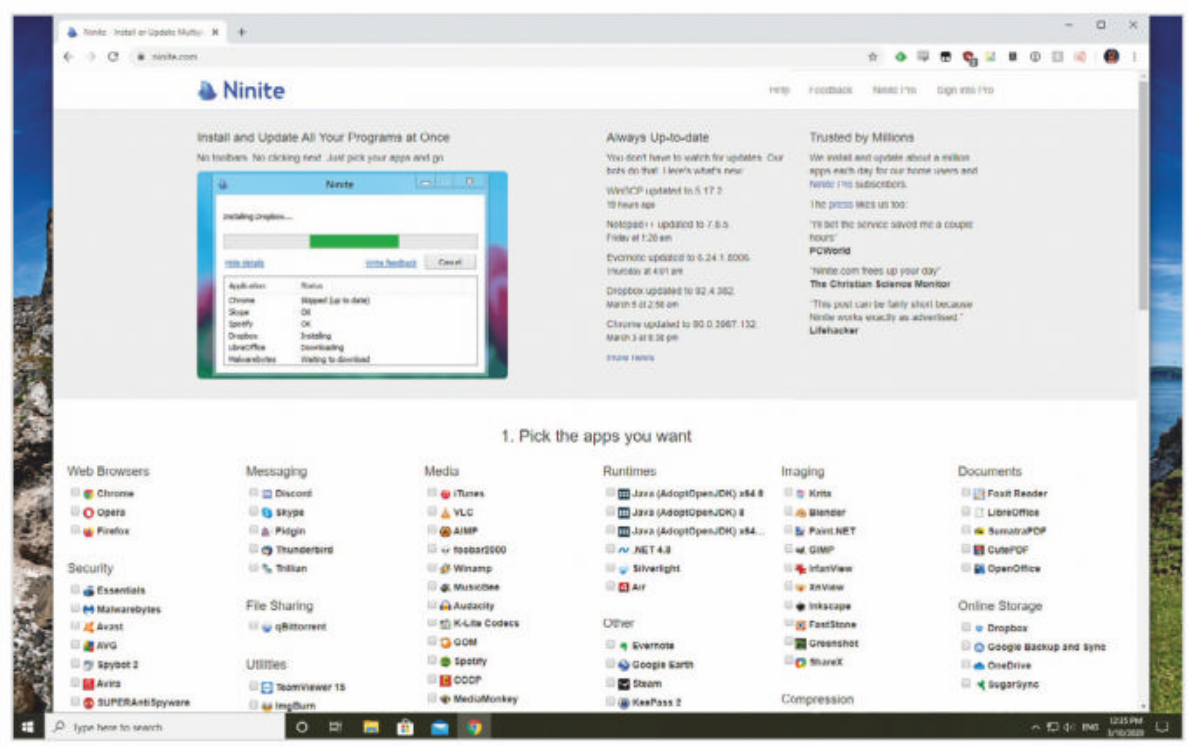
More than once in the past few years, Microsoft has pushed out a bad Windows update that caused chaos. If you're determined to keep your machine running on a certain patch – and if you're doing something mission-critical, this might be a good idea – you can use Microsoft's own Wushowhide tool to hide Windows Updates or wobbly device drivers from the auto-updater's prying eyes. **http://bit.ly/3cIA1Yo**

24 TestDisk

Don't be fooled by the name. While TestDisk is capable of testing disks, it's much more adept at pulling data from drives that are about to click their last, or those writable optical disks that have started to rot with age. Sure, it's not exactly pretty, and it's rarely quick to do the job, but TestDisk is an absolute essential for data recovery. **http://cgsecurity.org**

25 Eraser

If you don't want that data recovered ever, you probably already know that simply deleting a file isn't enough – it only really deletes the reference to the file, and it won't be gone until it's overwritten by something else. Eraser positively shreds that data, overwriting it with zeroes and ones repeatedly to ensure no trace of it is left. **http://eraser.heidi.ie**



There's a vast catalog of software available for quick install with Ninite.

Desktop extras

31 Cakewalk
Here's the story: Cakewalk started on DOS in 1987, spawned high-level digital audio workstation SONAR, its parent company got bought by Gibson, which gave up on the software, then BandLab snapped up the license, renamed SONAR back to Cakewalk, restarted development, and threw the whole thing online for free. It's a fantastic pro-level DAW worthy of all those commas. **http://bandlab.com**

32 Pro Tools First
We wouldn't use Cakewalk to record a podcast, but Pro Tools First, which is a cut-down tool based on the high-end audio workstation used in professional studios, is the perfect choice. It can pull in four audio inputs at once, which is great for separating individual mics, and the First version includes 23 high-end effects. **http://avid.com**

33 Audacity
For simplistic audio futzing, or cleaning up less-than-great recordings, Audacity's straightforward interface is just the thing – particularly given the greater complexity of full-on workstation packages. It's great for swift cuts and crops, snipping out coughs or hesitations, or just recording something simple and quick. **http://audacityteam.org**

34 GIMP
It wouldn't be a free software list without GIMP. That's not us being lazy (honest), but evidence of its brilliance – for a community-developed image editor, this is as good as you'll find. It's approaching the abilities of Adobe Photoshop, and while it might never reach those heady heights, it's also not going to cost you $343 a year to use it. **http://gimp.org**

35 Paint.NET
Microsoft seems determined to kill its own creative apps, but Paint.NET – which takes the Microsoft Paint formula and adds a host of power and functionality – remains determined to keep that simple dream alive. It might not have all the features and plugins that GIMP waves around, but it has enough to pull off a quick job. **http://getpaint.net**

36 Inkscape
Do you frequently edit vector graphics? You don't? Of course you don't. But if you ever do need to create a scalable illustration, the extra learning curve of Inkscape is probably worth the vast difference in price between this and Adobe Illustrator. Even if you don't think you need it, Inkscape's abilities as a planning and sketching tool are peerless. **http://inkscape.org**

Cakewalk incorporates its own software instruments and works with VST synths, too.

37 Scribus
We admit we're still waiting for someone to release a truly awesome free desktop publishing package, but if you've had it with Microsoft Word's inability to lay out a page properly, this well-seasoned DTP veteran will come in handy. Nearly 20 years down the line, it works perfectly well, but it's still a little rough around the edges. **http://scribus.net**

38 DaVinci Resolve
Another one with a steep barrier to entry, but don't let that stop you: DaVinci Resolve is a super-high-end video editor, inexplicably offered to you for free. It's adept at cutting and slicing, particularly with the new features in version 16, but it's primarily a grading tool – turning mixed footage into one consistent and colorful whole is a satisfying experience indeed. **http://blackmagicdesign.com**

39 Blender
Once (oddly) touted as a game engine, Blender has settled into its skin as a full 3D suite, with all the tools you need to construct models, and plenty of tech in there to allow you to rig, animate, and motion-track them, too. Its rendering engine is super-neat, and Blender can even act as a video editor and 2D animation suite in a pinch. **http://blender.org**

40 Daz 3D
Used by professionals but easy enough for anyone to get involved with, Daz 3D is another 3D renderer that gives you access to a whole lot of intricate detail and physics features. As far as we can see, it makes its money from asset sales, but as Daz also publishes the Hexagon modeling tool (also free), it's plausible to run a cost-free pipeline. **http://daz3d.com**

Supercharge your streaming

41 Streamlabs OBS
We've nothing against standard OBS but our preferred stream tool is Streamlabs' variant. It's neater, it's packed with handy filters, and it makes both configuring a stream layout and controlling your inputs and outputs straightforward. There's even a selection of (somewhat cheesy) templates to choose from to get you started. **http://streamlabs.com**

42 Lightstream Studio
If you want to quickly stream from a new computer, or don't want the hassle of installing anything, Lightstream is a very cool solution – it runs entirely within a web browser, and allows far more customisation over what you're showing than the rudimentary browser tools offered by YouTube or Facebook. There's a 720p limit and a watermark on the free tier, though. **http://golightstream.com**

43 Discord
Nothing builds a community like Discord, so whether you want to give viewers somewhere to go to bad-mouth you or you want to get other voices on your stream, Discord is an efficient way to do it. It's supplanted things like Skype and Slack for us; it's perfect even if you just want to set up a meme-heavy chat with buddies. **http://discordapp.com**

44 HexChat
You'll know Twitch chat as a rotten hellscape of awful icons and incessant shouting, but it's still useful for streamers who want to see who's backseating and who needs banning. HexChat, spiritual successor to mIRC, allows you view Twitch chat differently, to filter out the noise and see who's actually watching. **http://hexchat.github.io**

45 Twitch Tracker
Just how well has your stream performed? If you use Streamlabs OBS, you get a nice little report at the end of each session, and Twitch itself offers some insights, but for the rest of us, Twitch Tracker is a very handy tool. It's not restricted to just your own streams, either; you can use it to see what's hot, who's performing well, and a lot more besides. **http://twitchtracker.com**

Do deep-dive tweaking

46 Autoruns
Booting up a Windows PC has always been a bit of a gamble. If there's some program that's going to take its sweet time getting going, causing your machine to respond like it's drowned in syrup, Autoruns does a good job of stopping it. It allows you to get far more in-depth than Task Manager, as you can kill individual processes and Windows components too. **http://sysinternals.com**

47 Process Explorer
Task Manager is not a bad tool, but more detail is always good. Process Explorer gives you that; it allows you to break down exactly which DLLs and sub-processes those rogue programs are running, and it lets you act on them. Results are dependent on your knowledge and foolhardiness; use at your own risk. **http://sysinternals.com**

48 LockHunter
Malware (or just badly coded programs) can sometimes lock files on your system to stop them from being deleted. If you're suffering from such an issue, LockHunter does just what its name implies: It works out which process is stopping the deletion, and either allows you to kill the offending process or bypasses the lock to throw that file in your recycling bin. **http://lockhunter.com**

49 ShellExView
Shell extensions extend your Windows PC's right-click capabilities. That's great until it isn't; if you've got a right-click menu clogged up with a bunch of useless links to software you barely use, it could be time for a tidy. ShellExView shows you exactly which extensions you have installed, and allows you to disable and enable them at will. **http://nirsoft.net**

50 Everything
Oh Windows search, how poor you still are for some unknown reason. Everything lists absolutely everything on your system, every single file and folder, and filters it down as you type. So whether you're looking for a filename (quick) or the contents of a text file (far slower), it's a much better choice than that box on your taskbar. **http://voidtools.com**

Productivity

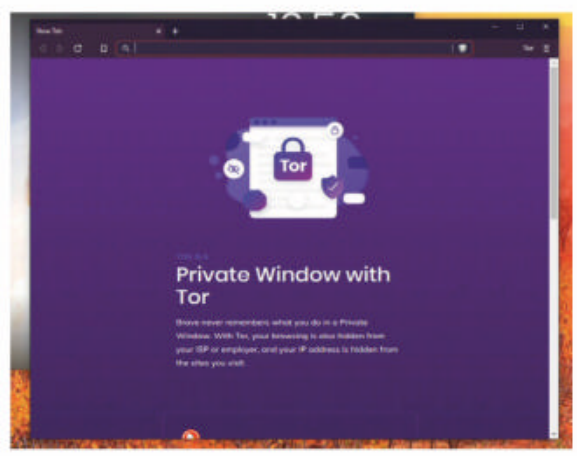
51 Brave Browser
One of the fastest rising browsers, Brave uses Chromium to render pages, but that's where its similarities to Chrome end. It's focused on privacy, from blocking ads and trackers to integrating a Tor-routed stealth mode. And if you rightly feel guilty about taking revenue away from sites, you can anonymously chip a little into the pot for them, too. **http://brave.com**

52 Rambox
In the past, we've recommended Franz for your multiple-chats-in-one-place needs, but Rambox seems to have superseded it. Not only is it a great way to communicate with those who refuse to move off legacy chat platforms, but it's a clever one-stop shop for a whole raft of apps – including those you add yourself, if you're clever enough. **http://rambox.pro**

53 LibreOffice
LibreOffice, OpenOffice, Calligra, MaximumOffice2K – they are all, with exception of that last one, solid free office packages based on the same codebase. But LibreOffice has settled down as the package with the strongest developer support, and we say it's the one to use if you want a Microsoft Office-esque experience for free. **http://libreoffice.org**

54 Google Docs
Don't want to work on the desktop? Google's online office suite is functional enough, and it's excellent for collaborative working. Each document gets its own chat room, and you can see what others are doing to a document in real time, including the placement of their cursor. Just don't use it to annoy your colleagues, eh? **http://docs.google.com**

55 Todoist
The further we get in this feature, the more it seems we're giving Microsoft a hard time, but here's the truth: Wunderlist used to be great, then Microsoft bought it, ignored it, started its own competing To-do app, and made it not quite as good. Thankfully, Todoist is around to provide a viable alternative for listing all those tasks you should have done yesterday. **http://todoist.com**



Privacy-focused Brave Browser is the best way to browse the web with confidence.

56 Notepad++
This is one of those must-installs. It's great for code, it's great for making notes, it's great for viewing text documents quickly, and it's super-optimised to boot. The developer claims that last point is because he's "trying to reduce the world carbon dioxide emissions" – a noble, tiny goal. **http://notepad-plus-plus.org**

57 IrfanView
For viewing, converting, batch processing, and making tweaks to images, IrfanView is about as good as it gets. It's not really a paint package or Photoshop alternative, but it's damn convenient, with a shell extension to put its most common features in your right-click menu and a host of plugins to extend its abilities. **http://irfanview.com**

58 FocusWriter
As *APC*'s beleaguered editor will tell you, some people struggle to focus on getting their work done. FocusWriter is the perfect antidote to procrastination, cutting out distractions, hiding away the menus, and giving you a blank page to fill with lovely words. That and some optional typewriter sound effects, which we recommend you leave switched off. **http://gottcode.org**

59 KeePass Password Safe
Security isn't an afterthought, and you should have a password manager. You're free to trust your precious logins to an online service like LastPass, and indeed that's the most convenient way to manage that data over multiple machines. But if you'd rather your credentials stayed out of the cloud, the open-source KeePass is the best choice. **http://keepass.info**

60 Malwarebytes
While we encourage staying clear of free antivirus packages, Malwarebytes' bad-stuff-sniffing abilities convince us this adjacent package is a worthy install. If you suspect there's something up, running it gives you an overview of anything worrying on your system. **http://malwarebytes.com**

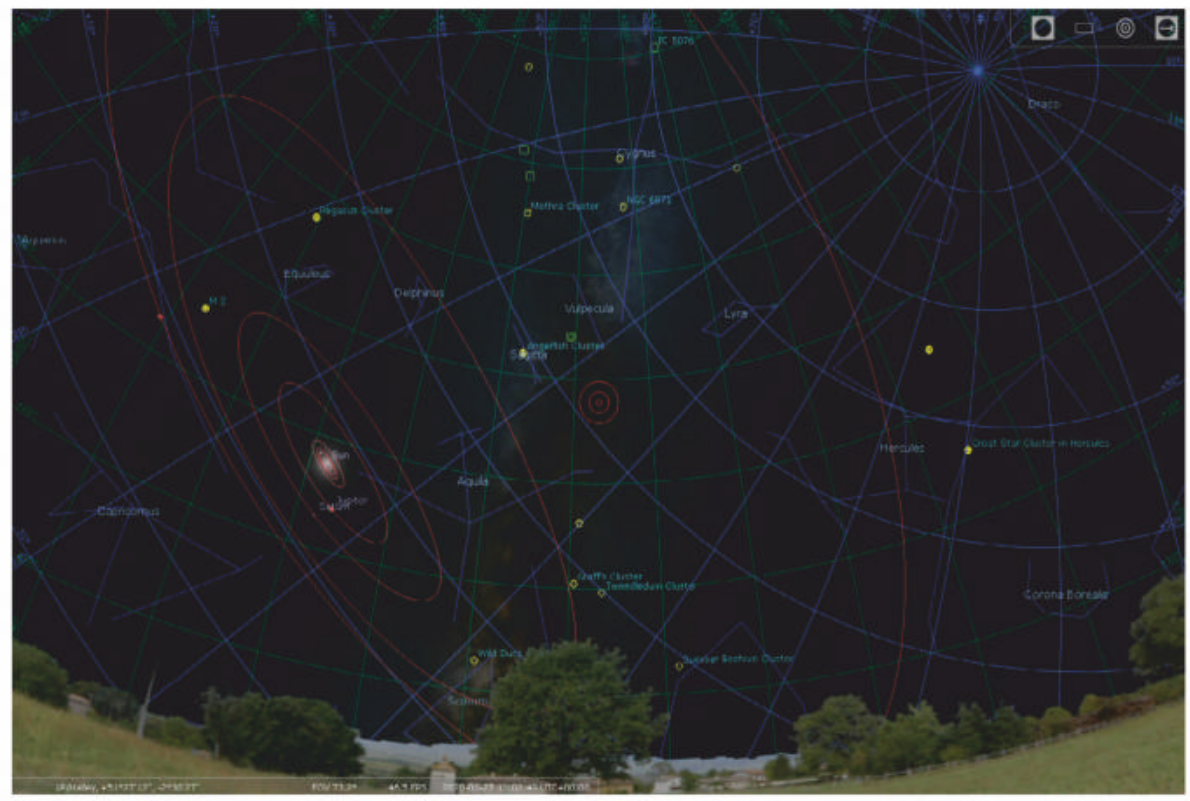
Taking it easy

61 Plex

You could opt for any one of a number of standard media players – VLC, PotPlayer, Media Player Classic, et al – but we don't understand why you would when setting up a Plex server is so easy. It gives you access to your media in your browser, and lets you stream it wherever you might want to watch it, with automatic transcoding depending on network quality. http://plex.tv

62 Subsonic

Today's streaming services mean this might have had its day in the sun already, but Subsonic is an audio-focused network player perfect for those keeping their music collection on a NAS. It includes a bunch of handy server features such as podcast catching and, indeed, conversion of playlists into downloadable podcasts – and you can share your library with others, too. http://subsonic.org



Open your eyes, look up to the skies, and see what's up there. Stellarium is fascinating.

63 Stellarium

Take a trip through the stars from your desktop with the excellent Stellarium, an interactive planetarium that can be extended to include a catalog of some 170 million stars. There are logging features for those with scopes pointed at the sky, and a web version at **http://stellarium-web.org**, but it's the desktop client that's the most rewarding and fun. http://stellarium.org

64 Google Earth VR

The greatest non-gaming use of VR there is, Google Earth VR can turn you from a towering mountain giant standing above Mount Everest to an insignificant human teetering on the edge of a skyscraper, and everything else between. Extra points for its peripheral vision fuzzing, which makes jumping from place to place a much less sickening experience. http://vr.google.com/earth

65 DOSBox

You shelled out a lot for that PC, didn't you? Such a shame. What you really need is an early '90s era DOS machine capable of playing Space Quest and Commander Keen, and DOSBox is all too willing to provide it. An x86 emulator for your x86 machine, it's easy to configure exactly to your liking – and if that means it pretends to be a 286 with CGA graphics, so be it. http://dosbox.com

66 LaunchBox

How many launchers for games do you need? If you're sick of hunting through Steam, Origin, Uplay, BNet, the Epic Games Launcher, et al for that one game you want to play, LaunchBox collects everything together in one attractive app. You can also use it to neatly launch emulated games, meaning it's great if you're setting up a PC for a younger user. http://launchbox-app.com

67 RetroArch

An emulator for just about everything, RetroArch cleverly makes use of what it calls "cores" – basically mini apps that contain the virtual guts of old computers and consoles – but retains your configuration between them. No need to remap controllers or move from emulator to emulator, just run your entirely legal and legitimate ROM file, and you're away. http://retroarch.com

68 F.Lux

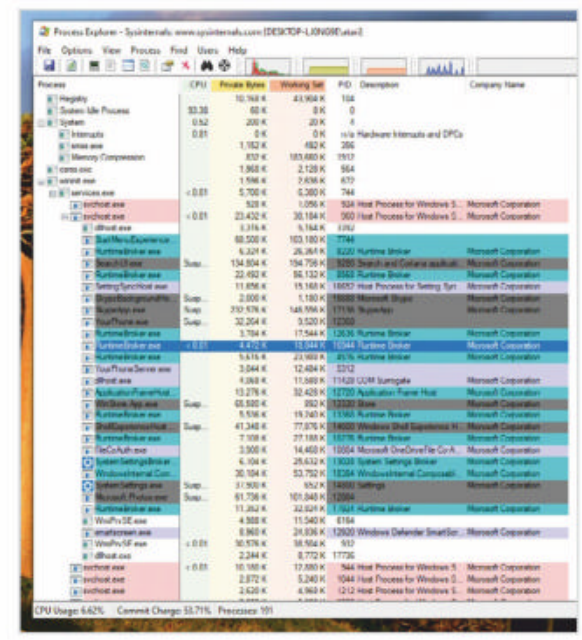
The scientific benefits of lowering the blue light output from your monitor are, at present, being hotly contested, but don't let that stop you from reducing eye strain in those evening hours. F.Lux can go further than Windows' built-in Night Light mode, going as warm as 800K, and it can even integrate with Philips Hue lights for a double dose of evening glow.
http://justgetflux.com

69 Duolingo

Modern language-learning is nothing like it was at school. Now you get coached by a weird little green owl, and even your earliest French lessons, funnily enough, give a strange prominence to the word "chouette." A brilliant thing, completely free, Duolingo turns vocabulary building into a game – and one you can play against your friends, too.
http://duolingo.com

70 ColorPic

Lest you accuse us of running out of ideas 70 applications in, here's a program that gives you the ability to pick out the color of absolutely any pixel on your screen. Want to do some CSS in Discord purple? Go for it. Want to tell what colour your cat really is? Eyedrop that sucker up. One of those things you'll never know you need until you need it – but when you need it, you'll be glad to have it.
http://iconico.com ■



Tell us, Process Explorer, what does Skype want with 250MB RAM?

REVIEWS

THE HOTTEST GEAR LABS TESTED

$3,599, gigabyte.com/au

Aorus 17G

Aorus is taking another early crack at the 2020 powerhouse gaming laptop category with a better cooling array and new 10th gen Intel chips.

A couple of years ago Aorus was producing some of the most sophisticated and desirable gaming laptop chassis available, but recently these classic designs have been stripped of all character and reassembled in Frankenstein-looking arrangements. Take the new 17G, which has four different styles of vents strewn around the cheap-feeling CNC aluminium veneer. While we're not particularly interested in having multiple different car grills slapped on our laptop, looks aren't everything in a gaming laptop, and I'm sure someone out there appreciates the mashup.

Fortunately there's plenty of other talking points for the Aorus 17G, like its inclusion of gold-plated Omron mechanical switches that offer a deep 2.5mm travel distance and light tactile click on actuation. Or maybe the lightning fast 240Hz 17.3 inch FullHD display with Pantone X-Rite colour calibration certified to have colour accuracy of a Delta E <1 will pique your interest (although you'll have to be ok with NTSC 72%, which is similar to standard sRGB).

SPECS

CPU: 2.3GHz Intel Core i7-10875H Graphics: Nvidia GeForce RTX 2070 Super Max-Q, RAM: 16GB DDR4 2,933MHz, Screen: 17-inch Full HD IPS, 240Hz, Storage: 512GB SSD (PCIe) Ports: 3 x USB 3.1 Gen1, HDMI-out, Gigabit Ethernet, 1 x Thunderbolt 3, 1 x UHS-II SD Card Reader, 1 x mini DisplayPort 1.4, Connectivity: Killer LAN E2600 (802.11ax).

If that didn't do it then maybe you'll appreciate the new Wi-Fi 6 capabilities via the latest Killer AX 1650 network card, offering up to 2.4Gbps transfer speeds on local networks.

While all of these perks are impressive, it wouldn't be an Aorus laptop without some serious internal components and the 17G doesn't disappoint on this front. There are five main variants available ranging from an Nvidia GeForce GTX 1660Ti all the way up to an RTX 2080 Super – although, only the Aorus 17G KB variant with an RTX 2060 GPU was available locally at the time of writing. This configuration offers the more efficient Intel Core i7-10875H (2.3-5.1GHz) CPU, 16GB of RAM and a 512GB PCIe SSD for $3,599. While this CPU is on the more powerful end of the spectrum, the RTX 2060 is perhaps a little under-specced when you consider you'll be wanting to push games to up and over 144Hz to make the most of the ultra-fast screen. We tested a unit with an RTX 2070 Super and that was only getting between 50 and 90 fps on modern games with 'ultra' settings and between 125 and 155fps on 'low' 1080p, so you really don't want a GPU any less powerful or you may as well opt for a less responsive screen.

In other regions you can actually bump the CPU up from the octa-core i7-10875H listed to a Core i9-10980HK. While this is obviously desirable for those needing the pinnacle of performance, the octa-core i7-10875H actually performed on par with the Core i9 chip from the early 2020 Aorus 17, which should be more than enough for most people.

While a number of the components on the early 2020 Aorus 17 were considerably more power hungry than the Aorus 17G KB, the battery life was close to double on the recent update. This was more than what we'd expected, offering four hours and 40 minutes on PCMark 8 Home Battery benchmarks and more than six hours on 1080p movie playback tests. JOEL BURGESS

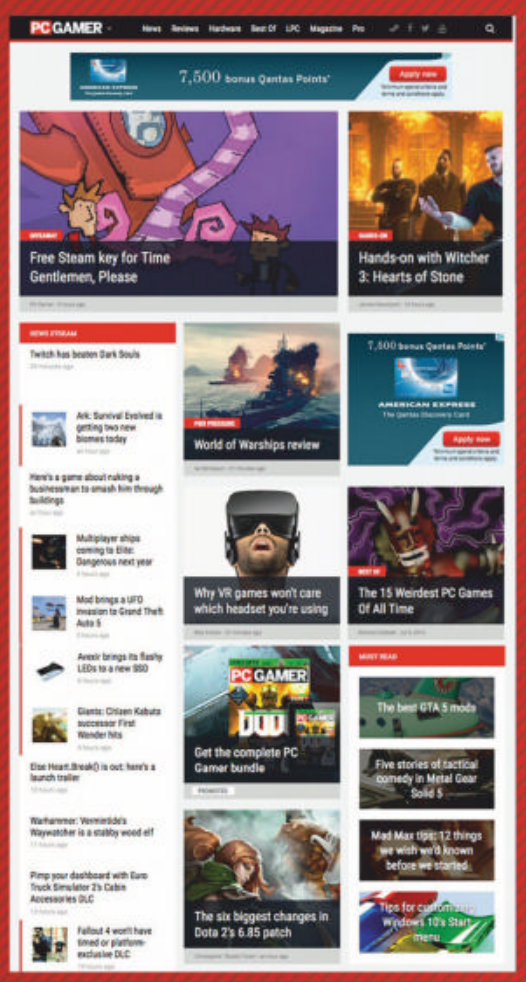
Indicates best result

		Aorus 17G	Aorus 17	MSI GT76 Titan DT95G
PCMark 8	Home (score)	4675	4665	3768
GeekBench 4	Single Core	5907	5818	6111
Cinebench R20	multi-threaded CPU	3450	3091	4910
3DMark Time Spy	score	7231	9,045	9,304
The Division 2	Ultra 1080p fps Av	66	91	81
Total War: Warhammer II	Ultra 1080p fps Av	71.5	89.3	98.8
CrystalDiskMark	Read(MB/s)	3363.2	2919.2	3208.5
CrystalDiskMark	Write (MB/s)	2983.4	1533.4	3004.5

A powerful, no expense spared gaming rig if you can get your hands on the 2070 or 2080 Super models, but the 2060 is a little light on GPU power.

★★★★☆

SMARTER COOKIES ENABLED



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$549, www.tp-link.com/au

TP-Link Archer AX50 AX3000 Wi-Fi Router

Bringing Wi-Fi 6 to the masses.

A few months back we reviewed Asus' RT-AX3000 router which was a largely unremarkable router but for the fact that it was the first unremarkable router we'd seen that supported Wi-Fi 6. In a market that was full of large, expensive, ostentatious, spiky-looking spaceships, it was the first, sober-looking 'affordable' model we'd seen. Now, here's a second soulless specimen from TP-Link. Could it be heralding Wi-Fi 6's market maturity and, if so, will that help the technology proliferate amongst the masses?

Our first impressions raised our hopes… this thing really is dull looking. You can even find it on sale as a 'white-box' unbranded product which typically means it's avoided visiting a decent, industrial design studio. It's a box with four, plasticy sticks sprouting from it. Routers looked like this on the small, hidden-away stands at Taiwan's Computex trade show back in 2005: so, we're off to a good start.

What's even better is that – completely unlike routers from 2005 – this one is simple to set up. You download an app, connect to the router and choose a name for its networks. However, there's no fancy SSID-binding here: you get to choose separate names for the 2.4GHz and 5GHz bands individually. If you don't like having two, you can turn one off. Beyond this, all standard Wi-Fi features are present plus Trend Micro network security and decent parental controls.

SPECS
Speed: Dual Band AX 3,000Mb/s; Connectivity: 4 Gigabit LAN, 1 x Gigabit WAN, 1 x USB 3.0; Features: Trend Micro Security, parental controls.

So far, there's not much difference between it and Asus's competitor, but Asus' router did have a trick up its sleeve: despite it achieving (very) disappointing speeds at distance, up close it managed the fastest, real-world transfer speeds we'd ever seen – 754MB/s! An Asus insider told us that the chips inside were actually over-specified. We took this to mean that Asus engineers didn't have any low-powered chips lying around for the budget product that their marketing department was demanding they build, to suit low-income demographics, so they threw in one of their some speedy chips.

But this is TP-Link who, in recent years, got bored of producing cheap, uninspiring Wi-Fi fodder and transformed into one of the very best, all-round Wi-Fi manufacturers in the world. Subsequently, while the company doesn't do bonkers Asus-like things, it does make thoughtful tech choices and we expected respectable performance from its middle-of-the-road device.

We ran our standard suite of Wi-Fi tests which involve downloading large video files from a Synology DS1019+ NAS to a Wi-Fi-6-equipped Dell XPS 15 OLED laptop in a three-storey Sydney Town House, using both 5Ghz and 2.4GHz bands, separately. Up close it managed a respectable, 387.5Mb/s and 273Mb/s (respectively); one floor up this dropped to 191Mb/s and 128Mb/s and two floors up it dropped to 157Mb/s and 86Mb/s. These are thoroughly mediocre scores... for Wi-Fi 6 routers. But, compared to standard, last-gen, AC routers (not the turbo-charged, premium variety) they're super-fast indeed.

So, is it worth buying? Asus's rival router is relatively cheap for Wi-Fi 6 at $400, but the AX50 costs just $280 which is arguably revolutionary: Wi-Fi 6 is finally available to the masses.

NICK ROSS

A dull but decent router that slashes the cost of entry to the world of Wi-Fi 6.

★★★★☆

$169, www.tp-link.com/au

TP-Link RE505X Wi-Fi 6 extender

Is a Wi-Fi 6-based range extender the best way to boost an existing Wi-Fi network?

We've been raving about Wi-Fi 6 for more than a year now: it made such a difference to speed and coverage when it first appeared that we needed to create new performance tests to measure it. But the barrier to entry has been high – not only do you need a laptop with a Wi-Fi 6 compatible chip to make the most of it, the routers themselves have, until the arrival of the TP-Link AX50 (page 44), been incredibly expensive. Along the road, two brands, in particular, have impressed us: TP-Link for its well-built, good-value, simple-to-use, high-performance routers and Asus for its super-charged, feature-packed units.

Not everybody wants to (or can afford to) overhaul their existing network and some just want to augment it with the power and reach afforded by Wi-Fi 6. To this end, TP-Link has released a Wi-Fi 6 range extender that works with any existing network.

The first thing to note is that this isn't the prettiest device and, as with many Wi-Fi extenders, it's a chonky boy that will likely get kicked out of the wall or tripped over if you mount it at floor level in a high-footfall area. Nonetheless, set-up is simple and can be performed either by pressing WPS buttons, using a web browser or downloading TP-Link's excellent Tether app.

Once you've told the unit which 2.4GHz and 5GHz networks you want to extend, they appear as separate networks with _EXT as a suffix. To be honest, we're a bit disappointed by this. We've got used to extenders seamlessly extending existing networks – having separate _EXT network names confuses devices as they often don't switch over easily; leaving you to stay connected to a weak host network instead. However, if you have a TP-Link router that supports the company's own, proprietary OneMesh technology, this won't be an issue.

The Extender is dual band and offers AX1500 speeds spread across 2.4GHz (300Mb/s) and 5GHz (1,200Mb/s) bands. Performance will greatly depend upon your source router but we ran our usual tests which involve transferring large files from a Synology DS1019+ NAS to a Wi-Fi-6-equipped Dell XPS 15 OLED laptop in a three-storey Sydney Town House via TP-Link's own AX50 Wi-Fi 6 router (on the ground floor) with the Extender one floor up.

SPECS
Speed: Dual-band AX 1,500Mb/s; Connectivity: 1x Gigabit Ethernet; Features: WPS

Near the Extender, across the 5GHz and 2.4GHz bands, the router managed 191Mb/s and 128Mb/s transfer speeds (respectively) while the Extender managed 215Mb/s and 110.7Mb/s. Two floors up, the router scored 157Mb/s and 86Mb/s while the Extender managed 130.6Mb/s and 60.2Mb/s. These aren't very significant speed gains and, in some instances, the Extender acts as speed hump. Nonetheless, if you're using a router with older technology, you'll likely see a much more noticeable performance boost (especially on the 5GHz band) as these figures are significantly superior to last-gen Extenders.

At $169, it's not cheap for an extender. But, in the context that it will likely do significantly more to fill Wi-Fi blackspots in your home than any similarly-priced rival, it's a success. As such, despite some foibles, it represents a good-value purchase.

NICK ROSS

A bit ugly, but it will boost a non-Wi-Fi 6 network better than similarly-priced alternatives.

★★★★☆

"Although the COVR system says that it will provide one seamless network throughout the entire home, it still needs an ethernet connection to an existing router: so it's similar to every other mesh."

$299, www.dlink.com.au

D-Link COVR 1102 Seamless Mesh Wi-Fi System

What's more futureproof? The latest last-gen tech or the current-generation?

We've been a little disappointed with D-Link's Wi-Fi products in recent months. For years, the company led the field but lately it's been floundering in Asus' and TP-Link's wake. Here's its latest mesh Wi-Fi system which D-Link tells us offers 'new' innovations like WPA3 security and Wi-Fi EasyMesh certification. Is this exciting enough to buy into?

WPA3 was actually released in July 2018 and this isn't the first device we've seen that uses it. Nonetheless, these technologies take time to hit the market and it's still not widespread. WPA3 uses SAE (which stands for Simultaneous Authentication of Equals security) to replace the Pre-Shared Key exchange protocol used in WPA2. It's more secure when connecting and more resistant to offline decryption-based attacks. This is a typically complex cryptographic way of saying it's the new WPA2.

Meanwhile W-Fi EasyMesh certification comes from the Wi-Fi alliance and (amongst other things) means that different equipment from different manufacturers can work together to boost the coverage of a network. This should help Wi-Fi mesh networks operate more efficiently.

SPECS
Speed: Dual-band AC 1,200Mb/s; Connectivity: 2x (2x Gigabit Ethernet); Features: Wi-Fi Certified EasyMesh

While WPA3 will be nice to have, few domestic users will experience the benefits. As for new Wi-Fi technology promises, we've come to be rather sceptical and find that the proof is in the performance. As such, we ran our usual suite of benchmarks which involve transferring large video files from a Synology DS1019+ NAS to a Wi-Fi-6-equipped Dell XPS 15 OLED laptop in a three-storey Sydney Town House. Although the COVR system says that it will provide one seamless network throughout the entire home, it still needs an ethernet connection to an existing router: so it's similar to every other mesh. Our kit only contained two nodes so one remained by the existing router while the other went one floor up.

Up close, it managed a respectable 246.5Mb/s. One floor up it managed a mediocre 71Mb/s. Nonetheless, two floors up (where there was no node) this only dropped to 68Mb/s. However, D-Link advises you to position the two nodes so that they face each other for a stronger connection. This might work well in a wide house, but it's more of an issue when it needs to beam the signal vertically up multiple storeys.

We're not convinced that directional Wi-Fi nodes is a good idea but it did make a difference – if they were on different surfaces or facing different directions then performance dropped between 30 and 40 per cent.

Performance aside, it's simple to setup via D-Link's Wi-Fi app but there aren't too many advanced features available in it. Nonetheless, there are good parental controls plus D-Link's typically impressive integration with Amazon Alexa and Google Assistant voice commands.

At $299 for two, modestly-performing nodes it represents reasonable value. However, we have concerns about futureproofing your Wi-Fi using the latest and greatest, last-gen technology. With TP-Link's Archer AX50 AX3000 Wi-Fi 6 router costing $280 and offering more-than double the performance at range – and it's expandable with nodes too – we recommend saving $10 and choosing that instead.

NICK ROSS

New technology designations mask modest last-gen performance in this mediocre mesh.

★★★☆☆

$350, www.draytek.com.au

DrayTek VigorAP 912C

A professional level access point with loads of features and mesh networking support.

Designed for business use, the VigorAP 912C is an affordable (~$350) wall or ceiling mount access point that can be used to create a mesh network. The sleek unit sports a single Gigabit LAN port equipped with Power over Ethernet (PoE), meaning it can be connected with one cable for reduced installation costs. It does come with a normal PSU in case your router doesn't support PoE, as well as a mounting support and template.

The access point has pretty typical specs; dual-band 802.11ac Wave 2 Wi-Fi with 2x2 MU-MIMO. In English, that means it can handle 867Mbps on the 5GHz band, and 300Mbps on the 2.4GHz band, and do so across multiple users at once. You can run the VigorAP 912C as a standard access point or range extender, but its real advantage is being used to create a mesh network.

First up though, some numbers. Using a Surface Pro and a Synology NAS, we copied data at 271Mbps at 2m range and 161Mbps at 8m distance (a few rooms away). These are solid speeds considering the hardware spec, aided by the access point being mounted up high. Sure, it might not impress those wanting multiple 4K streams, or gaming, it's perfect for general business or household use.

But what about that remote corner of the house or meeting room no one wants to use because the Wi-Fi sucks? The VigorAP 912C can be teamed up with a range of different smart access points from Draytek to create a mesh network. We tested with the VigorAP 802 – a compact little wall plug style AP that costs $150. Plug it in, use the DrayTek app to scan for mesh nodes and you are up and running in under a minute.

In our case, our spare bedroom Wi-Fi black hole went from 4Mbps (yes, it's that bad) to 94Mbps.

More importantly though is the mesh network topology. If you plug in multiple VigorAP 802 units (or other models in the VigorAP range) they all talk to each other to create a robust and fault tolerant network. That way, if Jim from accounting accidentally unplugs one AP to charge his electric scooter, the rest automatically reconfigure to fill the gap and still give the best possible coverage and bandwidth. The mesh network also seamlessly handles roaming between areas, switching you to the strongest signal.

SPECS
802.11ac 2x2 MIMO, AP, Mesh Network Range Extender; 1x PoE Gigabit LAN port, ceiling / wall mount

Setting up the VigorAP 912C is as easy as scanning the QR code with the much improved DrayTek Wireless app (Android or iOS), and running the wizard. For more in depth management, you are going to want to use the access points robust internal interface with a browser, use the included VigorConnect software, or manage it remotely via a Vigor router. The 912C has the access point features you need, such as supporting eight SSIDs, multiple virtual networks, a RADIUS server, airtime fairness, band steering and Wi-Fi scheduling.

The 912C doesn't provide the fastest, or longest range Wi-Fi, the app and software is a little utilitarian, but overall it provides an excellent experience and in depth features for a moderate price.

LINDSAY HANDMER

An affordable, functional, and easy to use access point that gets the job done with no fuss or bother.

★★★★☆

apc RECOMMENDS

$900, www.asus.com/au

Asus ZenWiFi AX XT8

Is the Wi-Fi 6 version of the excellent ZenWiFi a worthy upgrade over its impressive, AC-based sibling?

Regular readers will know that we've been devilishly impressed with Asus' mesh/router, cross-over devices. Starting with last year's, two-node RT-AX92U, the systems all utilise two small routers with a dedicated, wireless, backhaul connection. Our long-term testing has found that they provide a consistent wireless connection, to the other end of our home, that's as reliable as a wired connection. The end result is Wi-Fi coverage that is the fastest and most far-reaching on the market.

Last month we reviewed a more-refined and better-looking (and better named) version of the RT-AX92U: the ZenWiFi AC CT8. Although it was based upon the last-gen AC Wi-Fi standard, it still put up some seriously impressive numbers. Now here's the Wi-Fi 6 version – the ZenWiFi AX XT8. Our hopes were high.

Set-up is one of the simplest on the market. You download the Asus Wi-Fi app, turn on the primary node, it's detected by BlueTooth and sets itself up and updates automatically. To add the second node, you turn it on within three metres of the first node and it is automatically found, updated and connected. After that you can move it to the other end of your home and it will automatically connect over the dedicated, wireless backhaul channel.

SPECS
Speed: AX 6,600Mb/s; Connectivity: 2x (3x Gigabit LAN, 1x WAN, 1 x USB 3.0); Features: Trend Micro Security and family controls, Alexa compatible, IFTTT

The units themselves look suspiciously low-powered due to the lack of spiky antennae that usually adorn such high-performance routers. However, Asus makes the point that a great deal of thought and testing has gone into the design, with dedicated heatsinks and air vents cooling the quad-core processor and a bespoke antennae array producing optimum performance. But how does it perform in the real world?

Theoretical throughput is 6,600Mb/s which is spread across one 2.4GHz and two 5GHz bands. Our Wi-Fi test sees us downloading large video files from a Synology DS1019+ NAS to a Wi-Fi-6-equipped Dell XPS 15 OLED laptop in a three-storey Sydney Town House. At close range it managed a blistering 612.8Mb/s. One floor up (between the nodes) it scored a solid 450Mb/s, while on the top floor it only dropped to 445Mb/s. In short, it provides the largest, strongest, fastest and most reliable network that we've ever tested – and yet we're slightly disappointed.

It's AC-wireless-based sibling, which offers 2.2x less bandwidth plus a $550 price tag, offered similar speeds (albeit with slightly more signal fluctuation) at distance and still managed 503Mb/s up close. Considering that the ZenWiFi XT costs a whopping $900, that's a huge premium for improved network performance that hardly any domestic users will notice. Meanwhile, the original RT-AX92U Wi-Fi 6 system can now be had for under $700 and is very similar to the XT8 albeit somewhat uglier. As such the XT8 loses out on value.

There's still much to like; a full suite of Wi-Fi features are easily accessibly through the app and include good parental controls plus life-long Trend Micro network security protection. As such whichever ZenWiFi system you prefer, it's still the best way to spread high-performance LAN and WAN connections all the way to the other side of a home.

NICK ROSS

Fast, reliable speeds all the way to the other end of our house. But there's a huge price-premium over its marginally slower sibling.

★★★★☆

$699, msi.com

MSI Optix MAG272CQR

Is MSI's high refresh all-rounder flexible enough to bend to the local gaming PC market?

There's no shortage of competition in the 27-inch, high refresh rate gaming monitor space, and the MSI Optix MAG272CQR is neither the highest specced nor the best for your budget. Sitting somewhere in the middle of the pack, the most distinguishing feature is that it's curved (where the vast majority of competitors still opt for flat screen displays at this size). It's not a small curve either, with MSI opting for the tighter 1500R rather than a 1.8m radial arc. This may be a little divisive for hardcore gamers after the highest uniformity possible for competitive gaming, but if you're that way inclined you'll probably be opting for a 240Hz monitor.

MSI's Optix MAG272CQR - which is currently exclusive to JB HiFi – seems to have been designed to accommodate both high-level gaming while not being a compromise to work on. This balance makes a lot of sense since most people don't have a spare $700 to drop on a second gaming monitor and will need to use their display of choice for all that home office work as well.

To achieve this the MAG272CQR has been bumped up to a 2560 x 1440 pixel resolution to give you more clarity when looking at web pages and working on documents – without stretching into the expensive (and demanding) 4K territory. Complimenting this is a reasonable 300nit peak brightness and a HDR-ready specification that allows you to use Windows' baked-in HDR game and video settings. The MAG2727CQR only technically offers 8-bit colour processing, but it does include dithering, which essentially tries to replicate a deeper colour palate by using software to break colour blocks into shades of available colours to offer an amalgamated colour closer to a 10 or 12-bit image. There will be a noticeable difference between this and something offering true HDR, but it will be dramatically less noticeable than a screen that doesn't utilise dithering.

If you plan to play games at 1440p there is no real need for anything faster than 165Hz. We were only able to manage averages of 100fps on *Total War Warhammer II* using 1440p 'low' settings using a PC with an Nvidia RTX 2080, so you'll need to turn down the resolution if you're using a more affordable GPU in order to get the most out of the high-framerate screen. That said, less demanding shooters will be able to hit the upper limits of this framerate pretty easily for those with a dedicated GPU, and here it'll give you a solid competitive advantage. There have been some concerns about the speed of this VA panel not being quite up to the sub 1ms response time, but since it's not really designed for the most elite competitive gamers, we can't see this being a big issue.

If you want to save a bit of money and you're okay to lose a few milliseconds in response time you can get similarly specced monitors from Samsung and ViewSonic for $150 to $200 less, but if you really want to cut down on your pixel lag for better online gaming performance then there's no reason why you wouldn't go with this monitor.

JOEL BURGESS

"If you plan to play games at 1440p there is no real need for anything faster than 165Hz."

SPECS

27-inch VA LED panel @ 2560 x 1440 pixel resolution; 165Hz refresh rate; 1ms response time; 1500R curvature; 300nits peak brightness; 8-bit colour, 100% sRGB, 90% DCI-P3; 3000:1 contrast ratio; 61W power draw; 611.5 x 560 x 267 mm; 5.9kg.

A great all-round work and high refresh gaming monitor for mid to high end PC builds.

★★★★☆

apc HOT PRODUCT

$399, www.nvidia.com

Nvidia Shield TV Pro

Still the best streaming box on the market.

We're spoiled for choice when it comes to inexpensive streaming devices. But what if you're after a bit more 'oomph' from the gadgets serving your TV? Enter the 2020 edition of the Nvidia Shield TV Pro. An Android-powered set-top-box / games console, it's about as powerful as streaming devices come, and is jam-packed with features that will tempt movie and video game fans alike.

Whether you're after high-spec PC gaming streamed to your TV, or 4K movies in multiple HDR formats, it's got you covered. In the box you get the console itself, a new-and-improved remote control and access to 20 great (if ageing) PC games that can be streamed over the internet as part of the GeForce Now service, which you can expand upon with your own purchases.

The Nvidia Shield TV Pro is a tiny little thing, given the power it packs. Shaped like a slim wedge with some angular indentations carved into it for posterity, it's about the size of two Kindle e-readers stacked on top of each other. Around the back you'll find two USB 3.0 ports, a 4K HDR-compatible HDMI port, an Ethernet port and a proprietary power port. Wi-Fi is built-in (802.11ac dual-band) as is Bluetooth 5.0 for connecting wireless accessories.

Under the hood is 3GB of RAM and 16GB of storage. The RAM remains unchanged then, but we've seen other Shield models with as much as 500GB of on-board storage, so a little more here would have been appreciated. Still, the two USB ports make adding external storage a cinch, not to mention plugging in a wired controller or keyboard and mouse.

What's really changed then is the processor – the first major upgrade to the Shield TV range since it was introduced in 2015. On-board here is the Tegra X1+ processor – representing a 25% performance boost over the retiring Tegra X1, it's of the same family of chips currently powering the latest Nintendo Switch.

If you've used an Android TV device before, you'll know what to expect from the Nvidia Shield TV. It's pretty much the vanilla Android TV experience as Google designed it, with some small tweaks. The Shield TV Pro therefore gives you access to all the major streaming services in their 4K / HDR configurations, from Netflix to Amazon Prime Video and everything in between. There's also media server apps like Plex and a ton of Android TV games to try out.

Shield TV already supports plenty of HDR formats, but it now also can play back Dolby Vision content, a premium format that tweaks brightness and contrast levels using frame-by-frame metadata. It also means the Shield now supports both of Dolby's premium cinema formats, including Dolby Atmos audio. The second of the big additions is a new AI image upscaler that can be toggled on or off at the push of a button. It's fantastic, and transformative for content that's running below 4K resolution.

The new Shield TV Pro is unrivalled when it comes to its 4K HDR streaming capabilities, has wide app support thanks to its Android TV foundations, and is littered with potential for gamers. As a device then, it's almost unreservedly recommended.

GERALD LYNCH

A versatile and powerful streamer with Chromecast built in and great gaming features.

★★★★½

$319, fractal-design.com

Fractal Design Era

The Era is stylish, but airflow and build issues abound.

Fractal Design's Era breaks rank with the company's signature style, thanks in part to a collaboration with Intel. The Mini-ITX case comes in black, blue, and rose gold, fitted with a black tempered glass top panel. The chassis is also available in white and silver equipped with a wood top panel. All models feature an optional vented top for added airflow.

The chassis measures 325 x 166 x 310mm and tips the scales at 4kg. The glass top panel of the Era is darkly tinted, though the chassis comes with a second vented top panel for added airflow. Front panel I/O is fairly standard. You get two USB 3.0, a single USB 3.1 Gen 2 Type-C port, a headphone/mic jack and the power and reset buttons. The stylish asymmetrical front panel looks fantastic, though it lacks any holes for ventilation. Filters cover every intake fan mounting location and are easily removed for cleaning. The large filter that covers the fans directly under the top panel is magnetic. The side filters snap into place, and the bottom-mounted filters slide up and out after removing the side panels.

The Fractal Design Era works with a variety of internal layouts. The company offers five examples; ATX PSU / 240 mm, ATX PSU 120 mm, double 120 mm rad build, air build, and high-airflow layout. The problem is that each layout comes with trade-offs and compromises.

Using an ATX power supply means you lose the 3.5-inch hard drive mounting location on the SFX PSU mounting bracket and limits AIO coolers to 120 mm. Using a graphics card with anything larger than a stock-height cooler eliminates the possibility of mounting fans in the bottom of the case. And depending on the length of your ATX PSU, an ATX power supply could be an issue in general. Also, the rear 80 mm exhaust fan and the SFX PSU mount must be removed to install your motherboard.

It should also be noted that some aftermarket CPU coolers could interfere with the exhaust fan. As such, we highly recommend completely removing all the internal hard drive brackets, PSU mounts and the rear-mounted 80 mm fan before attempting to install any components in the Fractal Design Era.

The area behind the motherboard tray is extremely shallow and, aside from a couple of fan cables, there is little room for cable routing in this area. Making matters worse, the included I/O cables are way too long. The result is a large ball of cable clutter that impedes airflow and looks terrible.

The Fractal Design Era's extremely elegant design is definitely its biggest selling point. Builders looking to assemble a modest system with a focus on aesthetics over performance (say, a home theatre / living room PC) will love this case. Although the difficulties we encountered cannot be overlooked, careful planning and component selection can mitigate many of the issues we found with this chassis.

STEVEN LYNCH

"Builders looking to assemble a modest system with a focus on aesthetics over performance (say, a home theatre / living room PC) will love this case."

Fractal's Mini-ITX Era is worth considering. Just choose your parts carefully.

★★★☆☆

apc HOT PRODUCT

$449, www.canon.com.au

Canon Pixma TR150 with battery

Is Canon's portable Pixma a functional tool for road warriors or a mobile masterpiece?

Young folk might need informing that printers were once one of the hottest properties on the tech market: the notion that you could print-out high-street-quality photos, in your own home, was mind blowing. But, in an age where photos are mostly viewed on screens, few people need them anymore. Of course, we still use printers, it's just that they're mainly for office work. But office printers are big and bulky. What happens if you're on the road, meeting clients and need bespoke, paper contracts signed right there on the spot?

Canon's TR150 with battery certainly isn't the first mobile printer we've ever seen, but its output turned our heads. At 322 x 185 x 66mm and at 2.1Kg it's small, but still twice the size of mobile rivals. Fixing the portable battery to the back adds 25mm depth plus 200g weight but allows you to print away from the power point. The battery enables 36 pages of printing after 10 minutes of charging and can manage 300 pages on a full charge. An LED indicator lets you easily see how charged it is.

SPECS
4,800 x 1,200dpi colour inkjet; Speed: 9ipm (mono) 5.5ipm (colour); Connectivity: 802.11n Wi-Fi (direct and LAN), USB-C; 50-sheet paper tray capacity, 500 pages per month duty cycle; 322 x 210 x 66mm & 2.3KG with battery

Setting it up is simple thanks to walkthrough diagrams and videos delivered by Canon's online manual. You can use USB, Wi-Fi or direct Wi-Fi for connection, so it can easily work without wires too. The buttons are mostly self-explanatory and the 1.4-inch OLED screen gives you intuitive access to the settings menus when not defaulting to an ink-levels indicator.

It's fed using a $22 mono cartridge (code: PGI-35) that has a stated lifespan of 191 pages. The $38 combined-colour cartridge (code: CLI-36) is listed as supporting 249 pages. The ink uses Canon's ChromaLife100 technology which offers good fade resistance for dye-based ink.

We dusted down our highly technical printer tests to see what performance it could achieve. On A4, glossy photo paper it reproduced our complex, detailed and colourful test image in a respectable four minutes. What was more surprising, was that the result was one of the most accurate printouts in terms of colour, detail and fine grain that we've ever seen – that includes specialist photo printers with multiple ink tanks.

When it came to our 5% coverage mono document (which reflects an average, office printed page), it printed at a rate of seven pages per minute. Text was crisp and clear while graphs and lines were straight with no warping or banding. It rivals the output of top laser printers.

We also spent 1min 38secs printing a colourful, A4, Desktop Publishing document that is laden with graphics, white-on-black text, photos and colours. Ideally this test uses fine grain, high-quality printer paper, but it's worth seeing what it looks like on plain paper too. For the latter colours were rather washed out, even for plain paper, but detail was impressive. So long as you use the correct media for your desired output, the TR150's potential quality is brilliant.

At $449 it's not cheap, but if you need top-quality mobile printouts, it's the best, all-round device we've ever seen.

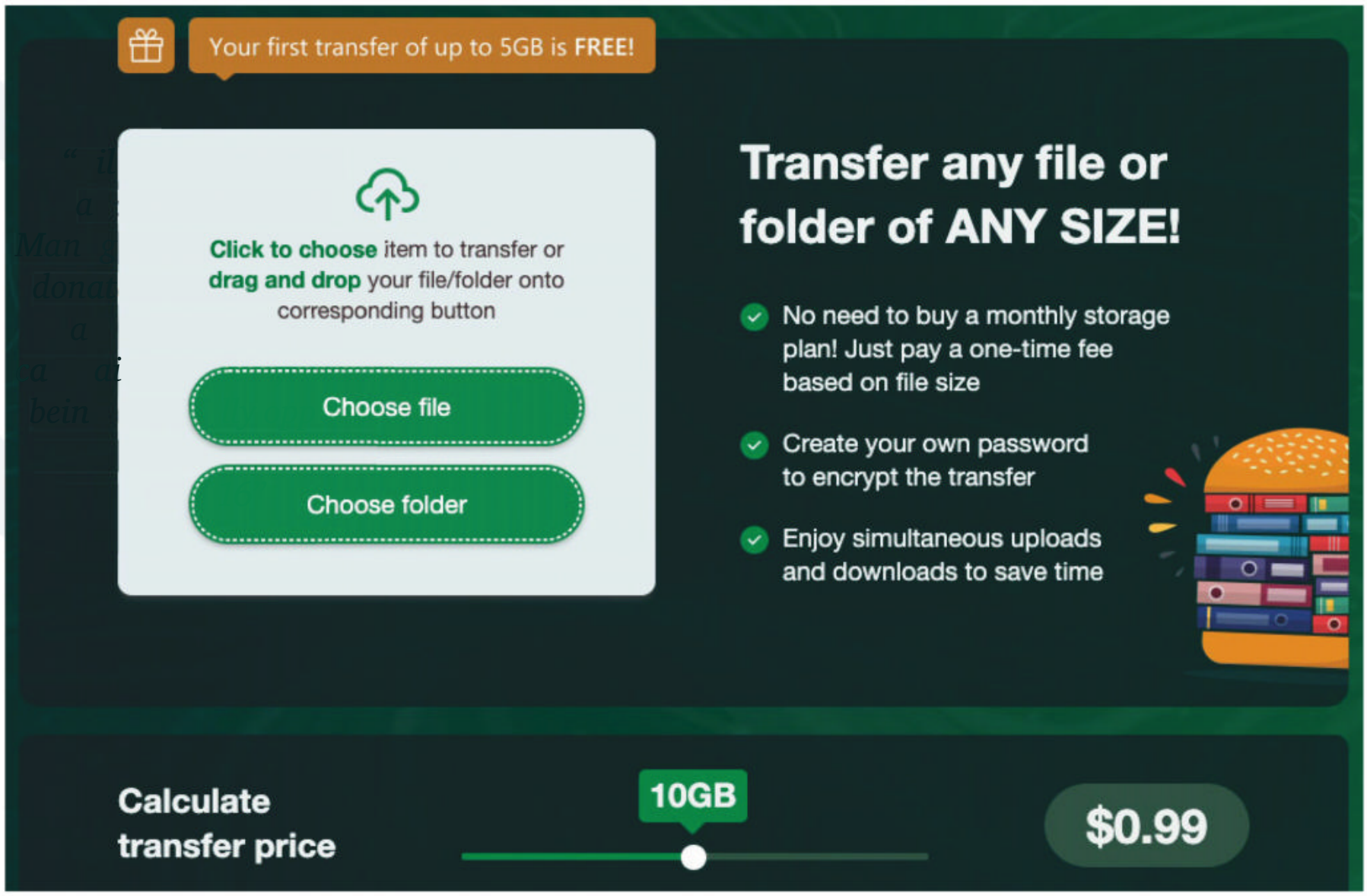
NICK ROSS

A well-specified, portable printer that can produce superb photos and top-quality documents.

★★★★★

SOFTWARE

APPS FOR ALL YOUR PLATFORMS



WINDOWS, From US$0.99 | filewhopper.com

Filewhopper

File transfers made simple.

FileWhopper isn't a cloud storage service in the traditional sense – it focuses on sharing files and folders rather than storing them, so it's perfect if you need to shift large amounts of data to another person without keeping them stored on the web for a long period.

To use FileWhopper, you do need to download a small application rather than using your browser – this is so interrupted uploads can be more easily resumed, and it means a smoother experience overall (the program can work in the background independently). The app deletes itself once the transfer is done, so no trace is left on your system. Unfortunately, the transfer tool is only available for Windows at the moment.

We do like the simple pricing structure of FileWhopper, and its simplicity in general. Files are kept on the web for 14 days, so the person you're sending the data to has a couple of weeks to get around to downloading it (this period can be extended, for a fee). You don't get any way of looking at your files on the web though, and there are no file or folder syncing features here.

FileWhopper is mostly simple and straightforward to use, and once you've picked your files or folders you then need to create an account (which is free). You're then directed to your account on the web, where you can see pending transfers and other details, and prompted to download the Windows upload tool.

After the upload is initiated, the FileWhopper app can be minimised to the tray. The program can automatically restart itself if your computer restarts, which is a nice touch, and can also shut down your PC for you if needed – handy if you want to leave an upload running overnight, for example.

Files and folders transferred through FileWhopper are encrypted using a password that you specify when you initiate the transfer – that means anyone who intercepts the file, including anyone from FileWhopper, won't be able to make sense of the data.

FileWhopper will let you send your first file transfer free of charge, if the amount of data you're shifting is less than 5GB. After that, you pay per transaction, depending on the size of your upload: anything up to 10GB costs US$0.99, for example, and 50GB costs US$3. You can go all the way up to 10TB if you need to, which will set you back US$126).

If you just need to occasionally shift some files around and don't want to be tied to a long-term cloud storage subscription plan, then FileWhopper is perfect. We were impressed with the speed of the software and the speed of the uploads, and transferring large files and folders – up to 10 terabytes! – couldn't be much easier.

DAVID NIELD

An appealing option if you want to transfer large files and folders to someone else, without having to sign up for a monthly subscription to a cloud storage service.

★★★☆☆

MACOS 10.13 or later, Free, offers in-app purchases, getdrafts.com

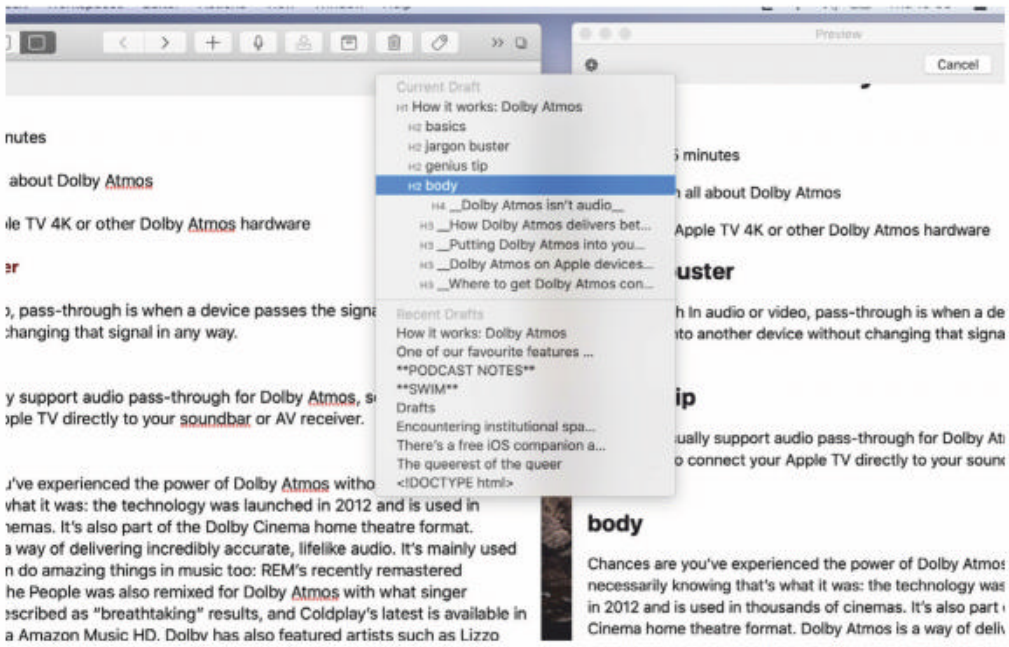
Drafts 17

Drafts was already good. Now it's great.

When we reviewed Drafts last year, we said it was a good note-taking and writing app that lacked the best features from its iOS sibling. Those features have now been added, alongside improvements including Touch Bar support and the ability to post to Medium.

Drafts is all about getting ideas down with minimum effort, and to that end it sits in your menu bar ready for action. You can use its icon to create a new draft ready to type, or create one from the contents of the clipboard, and you can add your note hands-free thanks to built-in dictation support. The app syncs with its iPhone, iPad and Apple Watch equivalents so you can create and view notes on the move.

Your drafts can be set up as Markdown, JavaScript, plain text, TaskPaper and more, and you can embed details including the location where you created your draft and the location where you've updated it. It's easy to reorder text, and professional writers will appreciate the subtle word and character count in the lower right-hand corner, as well as the customisation options that you can set differently for a variety of text formats. Some of these options are limited to Pro subscribers, so for example you can't override the system light/dark mode setting or use multiple workspaces if you're not a paying customer.



Drafts is a great environment with useful tools for all kinds of writing, from articles to code.

The headlines

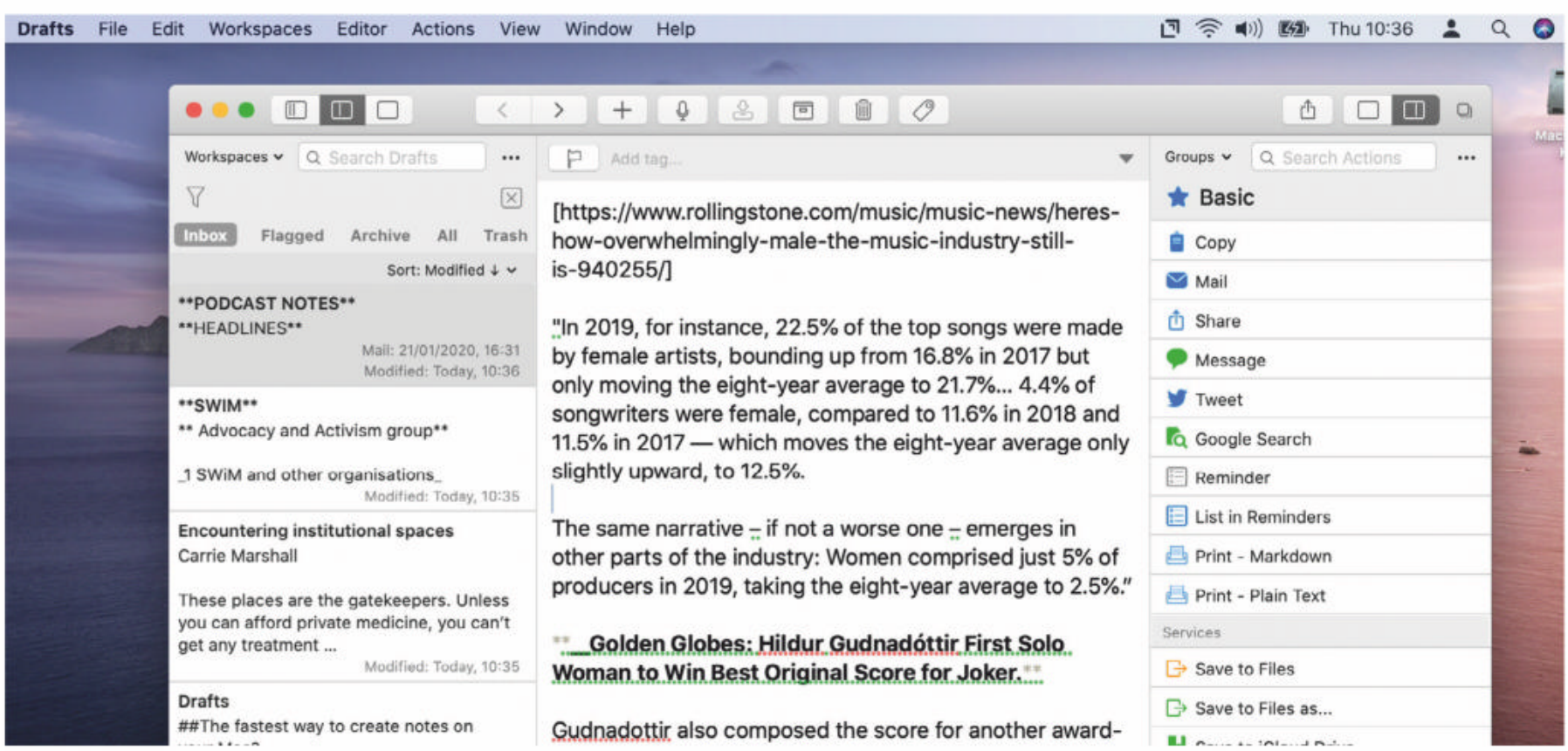
Where Drafts gets really clever is in Actions, the feature that was missing in last year's release. Actions connect your drafts to other apps and system features, so you can append your draft to an Evernote journal or a Google Doc, email it or send it to Twitter, change everything into Title Case, or post it to WordPress. Pro users can manage these actions, make their own actions, or add more from the online directory which includes Actions for tasks such as posting to Buffer, trimming white space, sending lists to the Reminders app, and hundreds more. Actions mean no two people's Drafts apps will be alike, and that you can tailor the app to do exactly what you want. If your Mac has a Touch Bar you can also access your actions from there.

Drafts was already excellent, now it's really standing out in its field.

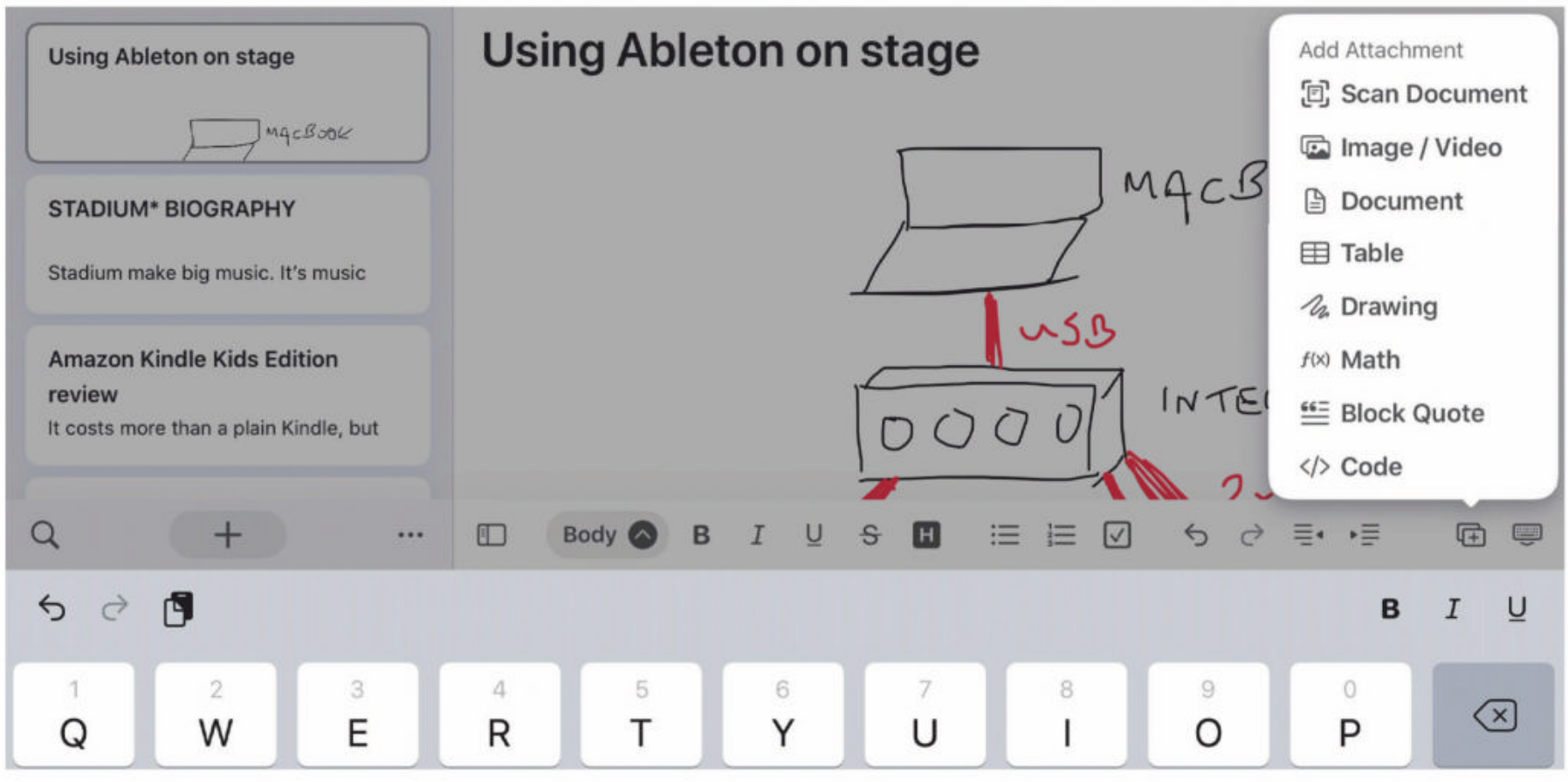
CARRIE MARSHALL

The new Drafts is an incredibly powerful and customisable note-taking app.

★★★★★



The addition of Actions (in the right sidebar) turns Drafts into a powerhouse.



IOS 13/IPADOS or later, Free (offers in-app purchases), noto.ink

Noto – Elegant Note

A useful all-rounder app.

Why use separate writing, note-taking and to-do apps when a single app can do all three? Noto is a simple, elegant writing app for iOS that can sync with its Mac sibling. Where most writing apps tend to go down the distraction-free route Noto is more colourful and action-packed.

The interface may be a bit more exuberant than its rivals, but Noto still has simplicity at heart. You can switch between list and grid views, reorder by dragging and pinning documents to the top, and easily nest docs in a folder. Each document has a preview that includes images (if they're at the top). On iPad there's a bit more room and the folders and documents appear in a sidebar rather than full screen; you can choose whether to keep the sidebar visible or to hide it.

In the main window you can carry out text formatting functions: bold, italic, underline, strikethrough and highlight, bulleted and numbered lists. There are formatting options for block quotes, code – including syntax highlighting – and mathematical equations, and when you're done you can export as HTML, PDF, or JPG. There's also a persistent word count feature, although Noto doesn't offer character count or estimated reading times.

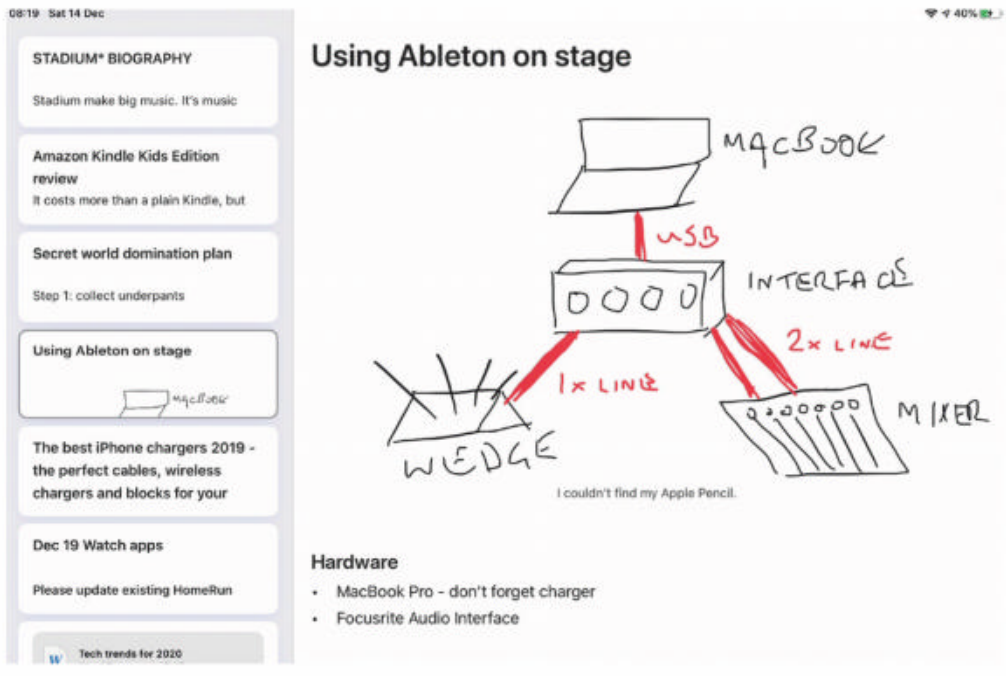
The formatting options include checkboxes and tables, so if you're planning a trip you could embed a map, create a to-do list, then detail the places you want to visit, then attach the necessary documents and booking confirmations. That turns it into a useful travel companion as well as an app for jotting down things you've experienced on your journey.

We reviewed Noto 1.0, and it's already as polished and useful as many more mature apps. If you go for the Pro version (99c per month/$9.99 per year/$24.99 for lifetime), you can also include attachments such as inline images, videos, or file attachments. It's no substitute for heavyweight writing apps or ecosystems such as Evernote, but if you want a simple writing app that covers the basics, Noto is definitely worth checking out: it's effective, easy, and free (or 'affordable' if you go for the Pro version).

CARRIE MARSHALL

In addition to text, Noto supports equations, tables, images, and file attachments.

apc RECOMMENDS

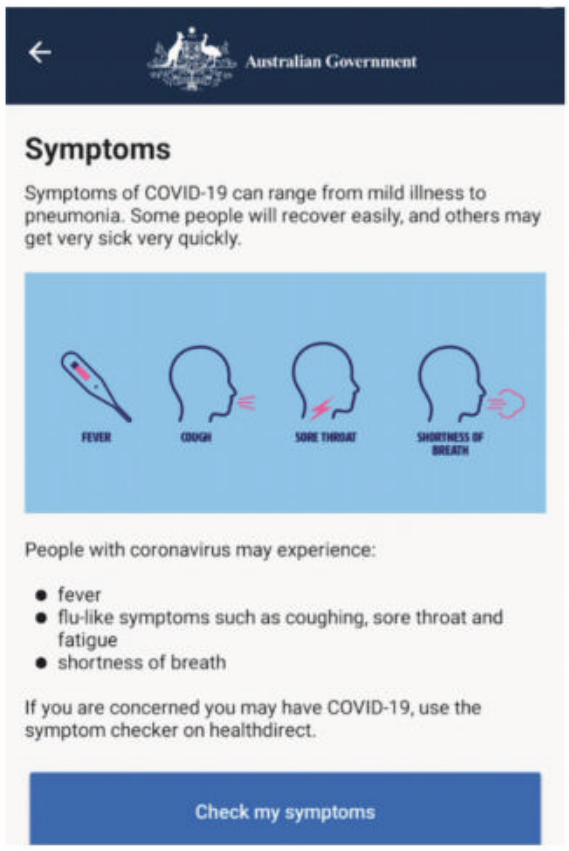


If you use Noto on iPad you get a simple two-panel layout; you can hide the sidebar if you want.

Noto is a simple and friendly writing app, but it also offers a lot of flexibility.

★★★★☆

"It provides stats on how many current cases there are per state, a symptom checker, and an advice section that links to articles about things such as financial support and getting tested."



ANDROID, Free, www.health.gov.au/resources/apps-and-tools/coronavirus-australia-app

Coronavirus Australia

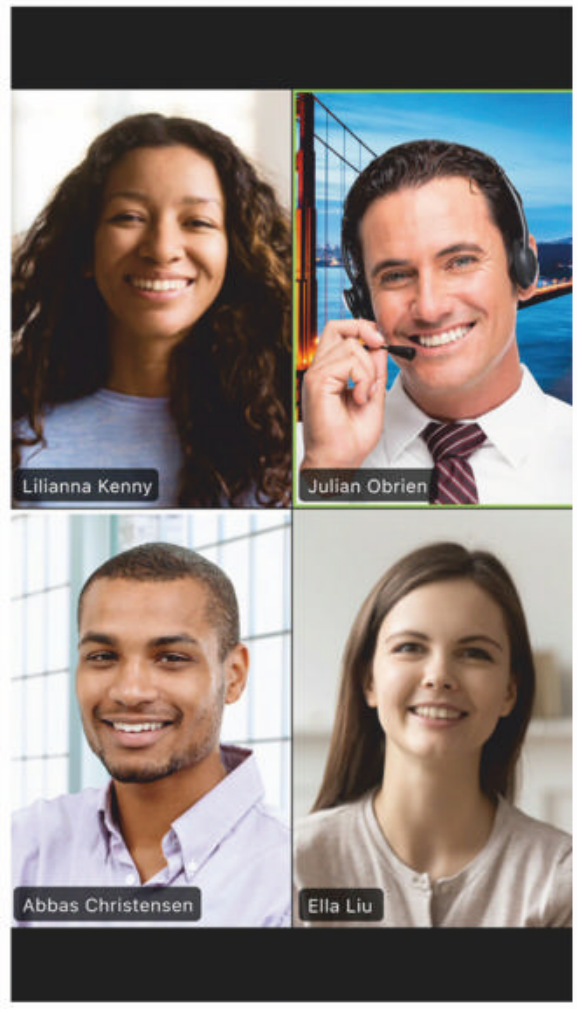
Government-approved.

This is the official app put out by the Australian Government to help citizens like you and I keep track of the situation with COVID-19. It provides stats on how many current cases there are per state, a symptom checker, and an advice section that links to articles about things such as financial support and getting tested. Unfortunately, it all falls down a bit as it's not very clear. You can click through to get to the website for information on what your state is allowed to do but there's no simple list of points as you might want or even expect. Even the website isn't as clear about that as most people would like. It also provides news from the government but it comes through many hours after it's already hit media everywhere else. The Coronavirus Australia app is a good one to have installed, but you can't rely on it completely. Definitely grab it but make sure you're checking other sources if you're concerned or unclear about the current pandemic.

HOPE CORRIGAN

★★☆☆☆

"Zoom is terrible in terms of security. It's so bad there are currently multiple class action lawsuits against it."



ANDROID, Free, zoom.us

Zoom Cloud Meetings

User beware.

Many people living the Work From Home life have recently become acquainted with Zoom, and though it's not a new app by any means I felt the need to talk about it here. Zoom is a video conferencing app that allows up to 100 people to use video and screen sharing to have meetings. Businesses are using it to keep their work flows flowing, and although it has a 4.0 rating on app stores, here's why you shouldn't. Zoom is terrible in terms of security. It's so bad there are currently multiple class action lawsuits against it. It's not just limited to people being able to jump into random conferences, but also many compromised accounts. There's reports of incomplete end-to-end encryption, data left freely visible on the web, and people are able to send dangerous files. If you care about you or your company's data even slightly, please, find something other than Zoom to use. I didn't even want to put it on my phone to get this screenshot.

HOPE CORRIGAN

★☆☆☆☆

"Microsoft Teams is also not exactly a new App but it is newly free, for now."

ANDROID, Free, teams.microsoft.com

Microsoft Teams

Not malware.

If I'm going to slam one app so hard, I feel the need to offer an alternative. Microsoft Teams is also not exactly a new App but it is newly free, for now. It comes in paid packs with Office 365 and other bundles (which most big businesses will have) but for right now, you can get on this bandwagon as a small business at no cost and also not risk your online security. It's also currently free for schools. Because it's linked with other Microsoft products there's a lot of integration, like being able to edit documents live while other people can watch and collaborate. Depending on what platform you're using you can also go into the files and add custom backgrounds for a bit of added fun. However, the main crux of Microsoft Teams is its video conferencing software backed by a large company that isn't essentially the same as injecting malware onto your device.

HOPE CORRIGAN

★★★★☆

AntiX 19.2

Jonni Bidwell is all for lightweight antics, but projects that make their initial letter lowercase are frowned upon here…

The antiX project has been around since 2007. It was originally built to provide a lightweight edition of Warren Woodford's KDE-based MEPIS distro family, an unsung hero in the battle to make Linux user friendly. MEPIS is no more, but antiX,now based on Debian stable, lives on. Its focus is still the same: to keep things light and useable. You may have heard of MX Linux (master of Distrowatch's ranking algorithms). That self-described "midweight" distro is based on antiX too, adding a slightly beefier desktop and a generous helping of applications. They share some documentation, which is a little confusing. However, most of the time Debian docs will be sufficient, and the tools unique to antiX are described on its website.

If you have old hardware, or just want to explore the realms of desktop frugality, antiX is a great place to start. The live environment (and we should say that antiX is ideal for using from a USB thanks to its persistence features) uses IceWM together with Rox (which provides desktop icons) to provide the rudiments of a desktop. You also get a nicely laid-out Conky, which draws system stats thereon.

There are hours of fun to be had borrowing and customising other people's Conky configurations, or flitting between IceWM themes. You can switch from IceWM to Fluxbox or JWM, and switch from Rox to SpaceFM (or be done with such desktop fripperies altogether) – all from the comfort of the (admittedly somewhat labyrinthine) menu.

AntiX is available in four editions. If the full edition is too large (our initial install used 3.3GB), then consider the Base, Core or Net editions. The installation wizard may look dated, but it's intuitive and somehow charming, and gets the job done. It took a second to notice, but it's actually nonlinear like modern installers: you can enter user and locale details while it's copying over. Once you're all installed you may wish to install a PAE kernel (if you're on 32-bit hardware) or perhaps use the antiX's bespoke tool to install a customised one from Liquorix or Siduction, or you can use a stock Debian effort.

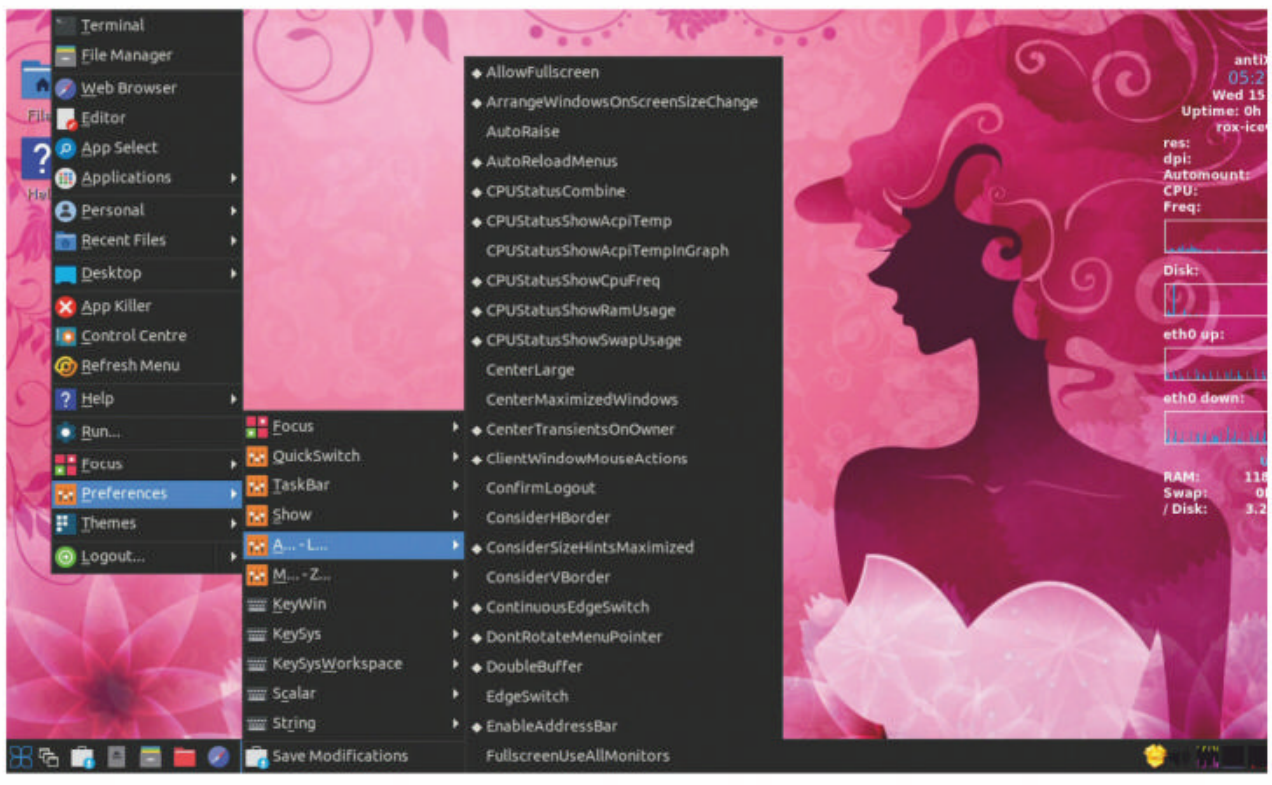
That small install footprint belies an impressive array of included applications. We won't list them all, but it's nice to have the choice between, for example, the lightweight Dillo browser and the console-based Links 2. Also included is a tool for managing Windows wireless drivers using ndiswrapper, which brought a nostalgic tear to our eye. And the surprisingly useful Droopy tool is ideal for sharing files over your LAN if you can't be bothered setting up Samba.

In the old days, not running a full desktop environment meant also doing away with such luxuries as USB automounting, an applications menu (or other means of creating one-click shortcuts to programs), or all those other handy utilities you don't think twice about (mixers, monitor settings, shutdown controls). Desktop Linux today provides some of that functionality through systemd, so it's nice that antiX manages to give you all that while standing out from the service manager monoculture. We had to dust off some old Debian documentation to remind ourselves how SysVinit scripts work. Like Debian, you're free to use another service manager, such as OpenRC, or indeed systemd.

Besides systemd, antiX also doesn't include Pulseaudio. On lightweight systems that aren't going to be doing audio-wise besides the occasional ding, this is entirely reasonable. But you might need it later on, if you don't fancy re-acquainting yourself with ALSA's dmix syntax.

JONNI BIDWELL

"If you have old hardware, or just want to explore the realms of desktop frugality, antiX is a great place to start."



Putting all the Conky options in two cascading menu will upset "UX-gurus", but who can argue with this pink background?

apc RECOMMENDS

In a world of diminishing options for 32-bit hardware, this is a great choice. It trips the light fantastic on modern kit, too.

★★★★☆

Core i5-10600K - $449, Core i9-10900K - $999, www.intel.com.au

Intel Core i9-10900K & Core i5-10600K

More of the same, but it is *more*.

It seems like recent Intel CPU generations have been akin to Plan B, C, and probably D. Most tech enthusiasts know that Intel should have had 10nm desktop products on the market a long time ago, along with a new architecture. 10th Gen is what it is, though, so rather than bash Intel, let's keep in mind that 10th generation CPUs actually are faster and have more threads at each price point compared to 9th Gen models. The real question is, is it enough when faced with an AMD that continues to gain momentum?

INTEL CORE I9-10900K SPECS
LGA1200; 10 Cores, 20 Threads; 3.7 GHz Base Clock, 5.3GHz Maximum Boost Clock; 20MB L3 Cache; 125W TDP; DDR4-2933 Memory Support, up to 128GB; Intel UHD Graphics 630

More threads and higher frequencies

Despite being an evolutionary upgrade, there are a few fundamental differences, including an improved thermal design with a thinner die and higher copper content heatspreader. The whole Core range now includes Hyperthreading, which adds significant value across the range, though truthfully Intel could have activated HT on i3 and i5 models years ago. Continual refining of the 14nm process means clock speeds are higher than ever and this alone is responsible for a lot of the performance uplift at the various price points.

Accompanying 10th generation CPUs is a new socket and chipset. We really would have liked drop in compatibility with 300 series chipsets, but the extra pins are required for power delivery reasons and unconfirmed future compatibility. Luckily, current LGA 115x coolers can be used with the new platform.

Meet the i9-10900k and i5-10600k

The headline is of course the release of the Core i9-10900K, a 10-core/20-thread model. It's got a 3.7GHz base clock, yet can boost as high as 5.3GHz on up to two cores if you keep the temperature under 70c. TDP has increased to 125W, but that figure is misleading as we recorded a figure of 228W when under default all-core load, which is 4.9 GHz. It's priced at $999 with a probable cooler purchase on top of that, which is a tough sell compared to the $779 Ryzen 3900X, which comes with its own cooler.

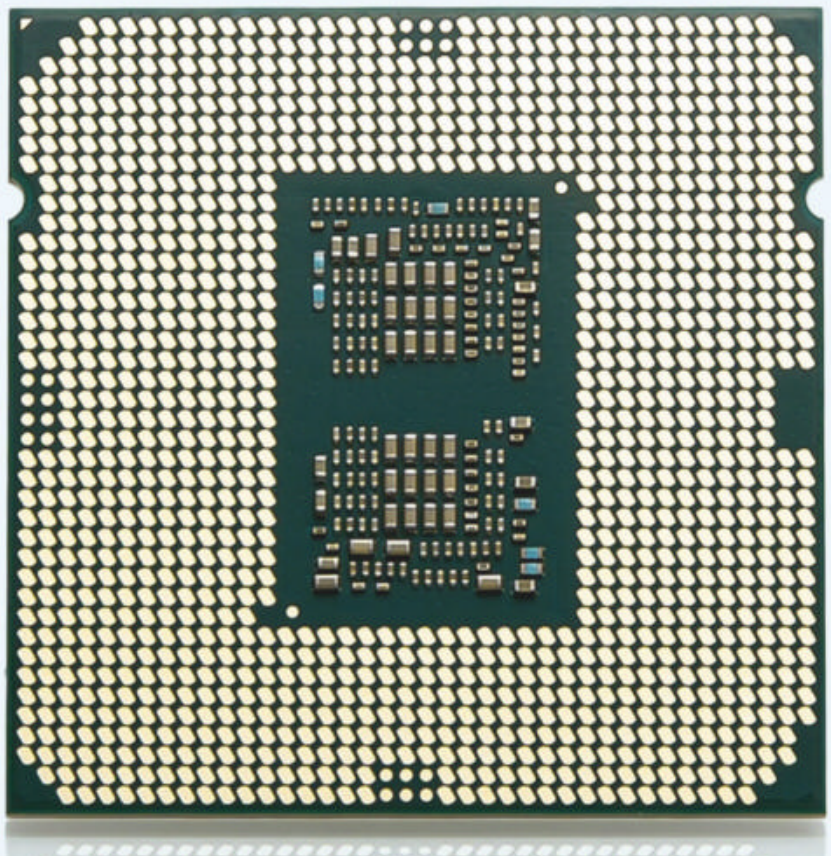
The Core 15-10600K is arguably the most interesting CPU in the whole range. It's a 6-core/12-thread model and it can be summed up as a slightly faster 8700K. It has a base frequency of 4.1 GHz and can boost up to 4.8, with an all-core boost of 4.5 GHz. Not bad for $499. It's also got a 125w TDP, however under all-core load, our sample actually came in at 113W, and hardly stressed our cooler at all. Impressive.

Gaming performance rules, but the competition remains tough

As expected, the 10900K is indeed the fastest gaming processor on the market right now. If you're serious about gaming, and run a high refresh rate monitor, then there's nothing better. Full load resulted in a temperature of 79C, which is not as bad as we thought it might be, but bear in mind we are using a high end AIO cooler, so it's safe to say a mid-range cooler will be seriously stretched by a stock 10900K under full load.

The 10900K goes up against the very capable AMD Ryzen 9 3900X, which offers two more cores yet comes in as much as 25% cheaper. Even when overclocked the 10900K cannot match its multi-threaded prowess.

The 10600K also fares well in gaming and it's a better 'frames per dollar' proposition. We were very surprised at how efficient the



"As expected, the 10900K is indeed the fastest gaming processor on the market right now. If you're serious about gaming, and run a high refresh rate monitor, then there's nothing better."

10600K was. Its power figures are quite reasonable at 112W under full load with the temperature at a perfectly acceptable 70C, which hardly stressed our cooler at all.

The 10600K is cheaper than the 3700X but faces price competition from below in the form of the 3600 and 3600X. Though they offer particularly good value, they are also 6-core models and only pull ahead in heavily multi-threaded scenarios.

Decent overclocking, though there's not much left in the tank

While time limitations prevented us from dialing in a truly stable 24/7 overclock, our 10900K was happy to run Cinebench at an all-core 5.2GHz at 1.3v (for a score of 6646). 1.3v isn't a particularly high voltage, however temperatures rise into the mid 80s even with our very capable 360mm Nzxt Kraken pump set to 100%. Peak CPU power draw was 261 watts. Look for power consumption to ramp up a lot when moving beyond 1.3v. It's clear that if you're looking at hitting 5.2GHz+ with full stability, you'll need top shelf cooling, a quality CPU sample, or both.

Our 10600K was less capable, with 5.1GHz bootable, but unstable even with 1.35v; however, running at 5.0GHz allowed us to drop the voltage back to a perfectly acceptable 1.3v. Cinebench returned a score of 3,924. If you're interested in overclocking, then a 10600K at 5GHz gives you a lot performance for its price.

We want something genuinely new

The 10900K does what Intel claims it does. It's the fastest gaming processor on the market but at $1,000, it's too expensive. If gaming is your primary task, you'll love it, however the 3900X delivers better multithreading performance for significantly less money and with a much lower power draw. Once the load moves on to the GPU, the difference in gaming performance becomes negligible anyway.

The 10600K is the more interesting model. At $499, it offers good value and very good gaming performance, particularly if you overclock it. It's got acceptable power draw and you don't need top-spec cooling to tame it. Along with the slightly cheaper 10600KF, it looks like the standout of the 10th generation range.

INTEL CORE I5-10600K SPECS
LGA1200; 6 Cores, 12 Threads; 4.1GHz Base Clock, 4.8GHz Maximum Boost Clock; 12MB L3 Cache; 125W TDP; DDR4-2666 Memory Support, up to 128GB; Intel UHD Graphics 630

If you're upgrading from an eight- or 10-year-old system, then you'll be amazed at the performance jump, but if you're on 6th generation or newer, there's little reason to upgrade. If you could drop a 10th gen CPU into a Z170 board that would be great, but, of course, you can't. Do you need more cores? Then AMD offers more cores at each price point.

What are we to make of Comet Lake? If you are a serious gamer, They are the best choice, but for everyone else, AMD still looks good from a price/performance perspective, plus there's 4th generation Ryzen on its way in the coming months. We're left waiting for something truly exciting and new from Intel. 10th Generation isn't it. Come on Intel, we want to be wowed. Please give us something new. *Really* new.
CHRIS SZEWCZYK

10th Generation CPUs aren't bad, but they're really more of the same, which leaves us underwhelmed.

Core i5-10600K
★★★★☆
Core i9-10900K
★★★½☆

INTEL CORE I9-10900K AND CORE I5-10600K

Indicates best result

		Intel Core i7-8700K	Intel Core i9-9900K	AMD Ryzen 7 3700X	AMD Ryzen 9 3900X	Intel Core i9-10900K	Intel Core i5-10600K
X264 v5.0 Video Encoding	Pass 2 Avg FPS	30.45	42.94	43.65	60.99	53.59	31.90
Cinebench 20	Multi-thread Score	3,396	4,940	4,864	7,191	6,327	3,583
Cinebench 20	Single-thread Score	474	502	487	509	534	499
Blender 2.79 BMW Render	Time (seconds) Lower is better	323.5	217.1	232.0	155.5	167.4	299.9
7Zip	Million Instruction per second	42,230	54,233	57,455	82,038	66,991	44,915
POV-Ray	Ray Tracing - Pixels Per Second	2,937.6	4,277.8	4,353.1	6,355.9	5,536.2	3,138.9
CPU-Z	Multi-thread Score	3,779.6	5,439.6	5,616.7	8,372.3	7,348.3	4,030.6
CPU-Z	Single-thread Score	489.4	549.6	529.4	548.0	579.5	528.0
SiSoft Sandra	Aggregate Memory Bandwidth (GB/s)	34.83	34.21	36.00	38.16	32.70	34.07
Handbrake Video Encoding	4K 10-Bit HEVC to 1080p FPS	50.5	60.0	59.3	66.6	66.1	53.4
Peak Power Consumption	Watts	111.2	153.9	90.1	144.5	230.7	112.7
AS SSD	Sequential Read MB/s	2,878.2	2,735.1	2,587.9	2634.6	2,986.1	2,872.8
AS SSD	Sequential Write MB/s	2,489.4	2,456.3	2,515.8	2503.9	2,556.4	2,535.7
AS SSD	4K Read MB/s	53.6	55.6	61.1	60.1	57.1	53.1
AS SSD	4K Write MB/s	152.6	145.4	209.0	217.6	161.1	152.4
3DMark TimeSpy Extreme		5,927	6456	6,319	6757	6738	6,030
3DMark TimeSpy Extreme CPU		3614	5114	4,572	6668	6,515	3,754
Civilization VI	1080p, Ultra, DX12, Avg FPS	163.4	186.9	178.0	174.2	191.6	179.8
Civilization VI	1080p, Ultra, DX12, Min FPS	102.5	126.6	130.7	126.8	128.3	126.4
Civilization VI	1080p, Ultra, DX12, AI Turn Time	6.26	6.05	6.29	6.29	5.97	6.18
Ghost Recon: Wildlands	1080p, Low, Avg FPS	194.4	202.8	193.8	195.5	211.9	201.1
Metro: Exodus	1080p, Ultra, DX12, Avg FPS	105.50	105.44	98.37	98.32	106.70	105.80
Metro: Exodus	1080p, Ultra, DX12, Min FPS	52.10	50.41	49.30	49.57	52.50	52.20
Middle Earth: Shadow Of War	1080p, Lowest Preset, Avg FPS	232	254	222	227	276	237
Far Cry New Dawn	4K Ultra Preset Avg FPS	79	80	77	78	79	80
Far Cry New Dawn	4K Ultra Preset Min FPS	65	67	65	65	66	66
3DMark TimeSpy		12,012	13,745	13,509	14,024	13,990	12,843
3DMark TimeSpy CPU		7,939	10,775	10,117	12,187	13,453	8,249

LAB ROUNDUP

Intel Z490 motherboards

A new platform for a new generation.

If you've made the decision to jump onto the Intel 10th Generation train, then you'll need a Z490 motherboard to go with it, at least until the budget chipset ranges are released. Z490 boards are equipped with the new LGA 1200 socket, and even the more affordable ones feature improved connectivity, networking, power delivery components and (take this with a grain of salt) future 11th generation CPU compatibility.

10th Generation CPUs may not have shaken the foundations of the tech world, but they are faster. It's important to consider the average consumers' point of view. Not everyone upgrades every year. If you're coming from something that's several years old then upgrading will get you a faster system in every way. Faster cores and more of them, faster networking, faster and higher capacity memory, faster storage and faster USB amongst other things. Upgrading from the 7th, 8th or 9th to 10th generation might not be a big leap, but 2nd to 10th generation sure is!

The K CPUs have 125W TDPs, though the higher core count models will actually pull a lot more power than that. This means that even budget Z490 motherboards are built with robust power delivery circuitry. Official memory support has been increased up to DDR4-2933 depending on the CPU model, though as we're dealing with a Z chipset, unlocked CPUs can run much higher than that. 2.5GB LAN and Wi-Fi 6 is also common across a lot of the range. It's about time too. Gigabit networking has been with us for well over 15 years!

One of the areas that Z490 might be seen as lacking is official PCIe 4.0 support, which is present on AMD's competing X570 platform. Some manufacturers are claiming PCIe 4.0 support on their Z490 boards, even though it is not supported by 10th generation CPUs and hence cannot be validated. Intel won't confirm any details one way or the other about its future products. When it is relevant, you'll probably see a Z590 chipset that's been designed and properly validated. PCIe 4.0 support on Z490 seems sketchy and it shouldn't factor into a purchase decision at this point in time.

What we're not impressed with is the upward trend in pricing. Just a year or so ago we were shocked to see a $1,000+ HEDT motherboard. While things like the Coronavirus and exchange rates are somewhat to blame, they're not the only reasons. Motherboard manufacturers are clearly happy to push the envelope with the big four manufacturers all offering boards valued at $1,500 or more. Z490 is still a mainstream chipset. We're not dealing with quad channel memory or a ton of PCIe lanes. Put simply, $1,000+ consumer motherboards are crazy. Still, people out there are buying them!

Moving on to the roundup, we have to say that choosing between motherboards in this class was very difficult. They all have their strengths and few weaknesses. Brand loyalty will perhaps be the deciding factor for many. We did pick a winner though! Read on as we look at some of the best Z490 motherboards on the market.

CHRIS SZEWCZYK

$689, www.asrock.com

Asrock Z490 Taichi

This Taichi has moved up to the premium tier.

Asrock's Taichi motherboards usually impress us. They're not promoted as the solution for a particular sub-market, but instead focus on key features while sticking to a more subtle design aesthetic that should appeal to all kinds of buyers. Can the Z490 Taichi offer the sweet spot value we've come to expect from the brand? At $689 though, it's now a premium level board, and it has to be judged as such.

The Z490 Taichi doesn't deviate too much looks-wise from its recent siblings. Why would you though with its lovely retro, almost analogue theme. It looks terrific. You get a nice splash of RGB lighting too of course.

The Taichi has a beefed up 15-phase VRM system fed by dual 8-pin power connectors designed to cope with the demands of 10th Gen processors. Each choke is rated for 60A, less than the 90A the MSI and Gigabyte offer. The Taichi incorporates no less than three small fans into the heatsink, though thankfully they are all but silent and couldn't be heard above the sound of our AIO CPU cooler and pump. When the board is presented with a light load, they don't spin at all.

SPECS
LGA 1200 socket; Support for Intel 10th Gen processors; 3x M.2; 8x SATA; Up to 4x USB 3.2 Gen 2, 9x USB 3.1 Gen 1; 802.11ax 2.4Gbps Wi-Fi; 1x HDMI, 1x DP 1.4; Realtek 2.5G and Intel 1G LAN; Realtek ALC1220 7.1 Channel HD Audio; ATX Form Factor

A generous abundance of ports, including HDMI and Display Port.

You get eight SATA connectors and three M.2 slots. Asrock is also touting its PCIe 4.0 readiness, though perhaps that's jumping the gun a bit with Intel not commenting on future compatibility or support at this time. It has a solid backplate and Asrock has redesigned the audio solution with an ESS DAC and WIMA capacitors all aimed at improving the SNR and performance with headphones.

High-end Z490 boards impress with their strong networking capabilities. The Z490 Taichi features Realtek 2.5G and Intel 1G LAN along with WiFi 6 to provide excellent networking flexibility. There's plenty of USB ports along with a PS/2 port and welcome HDMI and a DisplayPort. Though you probably won't use Integrated graphics on a $700 motherboard, it's good to have options.

The performance of the Taichi was interesting. It scored very well in bandwidth-sensitive applications, indicating that it sets aggressive memory sub timings. Our DDR4-4000 C16 test required a voltage bump in order to achieve stability too. The board easily pushed our 10900K to 5.2GHz on all cores, 5.3 is possible, though the heat from the CPU prevents stability, not the board itself.

At $689 it ticks almost all the boxes. It's got an intuitive, easy to navigate BIOS and a typically strong Taichi feature set. Its VRM isn't as strong as the other boards in the test and it's perhaps a BIOS update away from feeling really polished. Saying that is being tough on it, though. The Taichi is a strong offering.

It continues to offer good value and at $689 it's over a hundred dollars cheaper than the other boards in the test. That kind of pricing does erode a little of the Taichi's reputation as a mainstream value for money offering. Its competition isn't so much from above, as it is from below. When compared to strong contenders in the $500 to $600 range, the Taichi faces a different battle.

The Z490 Taichi is a very good motherboard, but it doesn't offer the killer value we've been spoiled with.

★★★★☆

$829, www.asus.com/au

Asus ROG Maximus XII Hero Wi-Fi

Typical ROG refinement.

It says a lot about Z490 motherboard pricing when the Hero – usually a value offering in the Asus Maximus range – sells for an eye watering $829. When compared to the Maximus XII Extreme though, the Hero is a true bargain!

The Maximus XII Hero doesn't look all that different to the outgoing XI Hero with the exception of a larger cooling assembly designed with multiple M.2 drives in mind. RGB seems to have been dialed down with the Z490 generation, with the Hero having just a couple of discreet RGB elements atop the chipset heatsink and I/O. It's also the only board in the roundup not to include a backplate.

The Hero comes with a 14+2 phase VRM design with each stage rated for 60A. It's not inferior so to speak, but the MSI and Gigabyte have a better VRM spec along with dual 8-pin power vs the 8+4 pin of the Hero. There's a bundled small cooling fan that you should install if you wish to push the board hard.

The networking features of the Hero are the best in our roundup, with Wi-Fi 6, Intel i219V 1G and Marvell Aquantia 5G ethernet. It's wonderful to see faster ethernet becoming widespread. The Hero has a very good selection of I/O ports including HDMI and plenty of USB. Is it time we saw an extra Type-C port on premium motherboards? Many laptops have Type-C only. Perhaps that's nitpicking.

Asus really goes the extra mile when it comes to BIOS features, though perhaps it can be overwhelming for novice users. If you want to tweak, and then tweak some more, then Asus has you covered. The Hero was effortlessly able to overclock our 10900K to 5.2GHz and our memory to DDR4-4000. Try as we might, 5.3 GHz is a step too far for our cooling. If you've got top shelf cooling, then the Hero will handle it. Our memory took exactly one try to get to DDR4-4000 16-16-16 which is a nice performance sweet spot. Don't forget that Asus offers the Maximus XII Apex if OC is your main game.

We're usually impressed with how ROG motherboards performance straight out of the box, and we used it for our CPU review. Its performance is exactly where we expected it to be, with all of the boards within a percent or two of each other.

We can't escape from the fact that the Maximus XII Hero is $829. Economic woes notwithstanding, that's a lot of money, particularly when the equally strong MSI and Gigabyte are a bit cheaper. Having said that, Asus rarely missteps with its ROG boards and the company has rightly earned itself a loyal band of followers who will hardly consider another board. If you choose the Hero you get the advantage of impressive 5G networking, excellent build quality and you'll have a capable and refined motherboard. Its VRM isn't class leading though, but that really only applies to extreme overclockers. We wish is was a few dollars cheaper but if you do go for the Maximus XII Hero, it will do your system justice.

SPECS
LGA 1200 socket; Support for Intel 10th Gen processors; 3x M.2; 6x SATA; Up to 5x USB 3.2 Gen 2, 6x USB 3.1 Gen 1, 6x USB 2.0; 1x HDMI, 1x DisplayPort; 802.11ax 2.4Gbps Wi-Fi; Intel I219V Gigabit and Marvell AQC111C 5G LAN; Realtek ALC1220 7.1 Channel HD Audio; ATX Form Factor

"The networking features of the Hero are the best in our roundup, with Wi-Fi 6, Intel i219V 1G and Marvell Aquantia 5G ethernet."

The Asus Maximus XII Hero is a solid board, but a touch pricey compared to the competition.
★★★★☆

$799, www.aorus.com

Gigabyte Z490 Aorus Master

A luxurious Aorus.

The first thing we noticed when taking the Z490 Aorus Master out of its box was its weight. This board gives the impression that it's built to last, and at $799 we'd certainly hope it does! For the money, it's clear the Master is a lot of motherboard. Interestingly, where some Aorus boards tend to light up like a laser light show, the Master really dials down the RGB with just a little bit of subtle lighting over the rear I/O and the chipset heatsink. The overall look is very understated, modern, and mature.

The Master features a very strong VRM, with a 14 Phase 90A design fed by dual 8-pin power connectors. The VRM is cooled by a traditional finned heatsink assembly, something we love to see as it really increases the heatsink surface area. It's the only board in the lineup not to feature active cooling, though it's optional on the Asus.

The Master has no less than 10 USB ports on the back panel, the most of any board in the roundup. It's also the only board to have a single LAN port, though it is a quality Intel 2.5G controller. It does have Wi-Fi 6, but if dual LAN is important to you, you'll have to look elsewhere.

SPECS

LGA 1200 socket; Support for Intel 10th Gen processors; 3x M.2; 6x SATA; Up to 5x USB 3.2 Gen 2, 4x USB 3.1 Gen 1, 8x USB 2.0; 1x HDMI; 802.11ax 2.4Gbps Wi-Fi; Intel I225V 2.5G LAN; Realtek ALC1220 7.1 Channel HD Audio; ATX Form Factor

A full ten USB ports are on the back panel!

We're usually impressed with Gigabyte's audio and that's also the case here, with an ESS Sabre DAC and quality component choices. You also get the fairly standard 6 SATA ports and triple M.2 slots which distinctively feature thermal padding for both sides of the drive. A nice touch. Note that Gigabyte is also touting its PCIe 4.0 support, though as we said in the intro, it's not something that should factor into a purchase decision.

Gigabyte has tweaked its BIOS layout. It has a fresh aesthetic and now feels more accessible to inexperienced users, yet is still packed with functionality. It also mature too, with the board able to handle our 5.2GHz all core OC and DDR4-4000 C16 with no hiccup. We didn't see any issue hitting 5.3GHz with Intel's boost either, but running 5.3GHz on all cores simply isn't possible with our cooling. It's certainly not the fault of the board.

Perhaps the only drawback, and honestly it's hard to even call it that when the differences are so small, was that performance tended to trail the pack in many cases. It's nothing to worry about, but when you're comparing motherboards that are all genuinely strong contenders, you have to look for some differentiation, and for the Aorus, this is it. Don't let it deter you from buying the board though. Perhaps a simple BIOS update could put it in the lead.

The Z490 Aorus Master comes across as a very solid, refined and exceptionally well built motherboard. Its VRM is excellent, and unless you need dual LAN we find very little to dislike about the Aorus Master. It's a board we'd be proud to own. Heck if it was $50 cheaper, it would probably be the roundup winner!

The Z490 Aorus Master oozes appeal but it needs to be a few dollars cheaper to make it our pick.

★★★★☆

$799, www.msi.com

MSI MEG Z490 Ace

The ace in the hole.

MSI can tend to overhype the gaming aspect of its products, but then all manufacturers have been doing that as it's a vital market for PC manufacturers. But don't let that make you think MSI are good for gaming only. On the contrary, some of their products truly are best in class. We think the MSI MEG Z490 Ace is one of those products.

The Z490 Ace looks great with its subtle gold highlights and metallic elements. It's good to have the primary M.2 slot above the GPU rather than cooking away underneath it. Other little things like the white post code display, fast booting and excellent fan control make the Ace across as a really refined and polished product. Even the M.2 installation is easy, with no need to remove a heap of screws and half of the entire heatsink.

The Ace has loads of connectivity and a fully featured I/O, as you'd expect from a board in this price range. About the only thing we'd like to see is 5G LAN, but with 2.5G and 1G plus the Wi-Fi, we don't mind that so much. There's up to eight USB ports on the rear panel plus a PS/2 and BIOS clear and flashback buttons. MSI includes the ESS Sabre DAC and dedicated headphone amplifier as part of its quality audio solution. There's not really much more you could want unless you jump up to the Godlike, which is, if you can you believe it, $700 more.

MSI has knocked it out of the park with the Ace's very strong VRM design. Dual 8-pin power connectors feed a 16+1 phase 90A design that's cooled by big chunks of heatsink. It's got a small fan that only spins up when it's required. There's also rear mosfet baseplates. You can overclock to your heart's content. Does any Z490 motherboard have a genuinely better VRM?

MSI's BIOS hasn't fundamentally changed much for several generations, and why would it? It's a very well laid out and intuitive system that doesn't make a user feel lost in menus within menus within menus. MSI also gets points for its excellent fan controls.

The Ace performed well, particularly under lighter loads where it was clear that the 5.3GHz Thermal Velocity Boost was functioning well. We expect all modern motherboards to perform within a percent or two and that was the case here. Overclocking a 10900K is almost entirely cooling dependent, and the MSI didn't break a sweat when pushing to 5.2GHz on all cores. DDR4-4000 C16 wasn't a problem either.

Choosing a winner between the Gigabyte and MSI, and for that matter the Asus and Asrock too proved to be exceptionally hard. A thing as simple as brand loyalty might be the deciding factor. We have to pick a winner though, and it's the MSI. Its excellent finish, well laid out BIOS, feature set, top class VRM design, performance efficiency and capable overclocking means all boxes are ticked, as it should be if you're going to drop $800(!) on a motherboard. Ace by name, Ace by nature. Well done MSI.

SPECS

LGA 1200 socket; Support for Intel 10th Gen processors; 3x M.2; 6x SATA; Up to 5x USB 3.2 Gen 2, 4x USB 3.2 Gen 1, 6x USB 2.0; 802.11ax 2.4Gbps Wi-Fi; Intel I219V 1G and Realtek 8215B 2.5G LAN; Realtek ALC1220 7.1 Channel HD Audio; ATX Form Factor

"The Ace has loads of connectivity and a fully featured I/O, as you'd expect from a board in this price range"

MSI's MEG Z490 Ace takes out the top gong and ticks all the boxes you'd expect on a motherboard at this level.

★★★★½

Z490 MOTHERBOARD BENCHMARKS

Indicates best result




		MSI MEG Z490 Ace	Gagabyte Z490 Aorus Master	Asrock Z490 Taichi	Asus ROG Maximus XII Hero Wi-Fi
X264 v5.0 Video Encoding	Pass 2 Avg FPS	53.65	53.63	53.77	53.59
Cinebench 20	Multi thread Score	6,304	6,304	6,352	6,327
Cinebench 20	Single thread Score	537	530	535	534
Blender 2.79 BMW Render	Time (seconds) Lower is better	168.0	166.2	167.0	167.4
7Zip	Million Instruction per second	66,453	66,366	67,740	66,991
POV-Ray	Ray Tracing - Pixels Per Second	5,554.1	5,532.7	5,496.8	5,536.2
CPU-Z	Multi Thread Score	7,310.0	7,318.6	7,327.6	7,348.3
CPU-Z	Single Thread Score	576.0	573.8	574.0	579.5
SiSoft Sandra	Aggregate Memory Bandwidth (GB/s)	33.30	33.27	33.74	32.70
Handbrake Video Encoding	4K 10-Bit HEVC to 1080p FPS	66.8	66.0	67.4	66.1
AS SSD	Sequential Read MB/s	2,920.1	2,912.0	2,899.8	2,986.1
AS SSD	Sequential Write MB/s	2,506.1	2,490.7	2,428.5	2,556.4
AS SSD	4K Read MB/s	55.9	56.4	53.2	57.1
AS SSD	4K Write MB/s	156.0	163.9	149.2	161.1
3DMark TimeSpy Extreme		6,698	6,685	6,703	6738
3DMark TimeSpy Extreme CPU		6,509	6,520	6,618	6,515
Civilization VI	1080p, Ultra, DX12, Avg FPS	190.3	190.3	193.2	191.6
Civilization VI	1080p, Ultra, DX12, Min FPS	124.6	126.7	127.1	128.3
Civilization VI	1080p, Ultra, DX12, AI Turn Time	6.10	6.03	6.11	5.97
Ghost Recon: Wildlands	1080p, Low, Avg FPS	210.2	208.2	206.9	211.9
Metro: Exodus	1080p, Ultra, DX12, Avg FPS	106.41	105.10	106.12	106.70
Metro: Exodus	1080p, Ultra, DX12, Min FPS	53.38	50.40	53.57	52.50
Middle Earth: Shadow Of War	1080p, Lowest Preset, Avg FPS	278	272	281	276
Far Cry New Dawn	4K Ultra Preset Avg FPS	79	78	78	79
Far Cry New Dawn	4K Ultra Preset Min FPS	66	64	66	66
3DMark TimeSpy		14,027	13,927	14,299	13,990
3DMark TimeSpy CPU		13,435	13,470	13,850	13,453

THE ULTIMATE GUIDE TO LIQUID COOLING YOUR PC

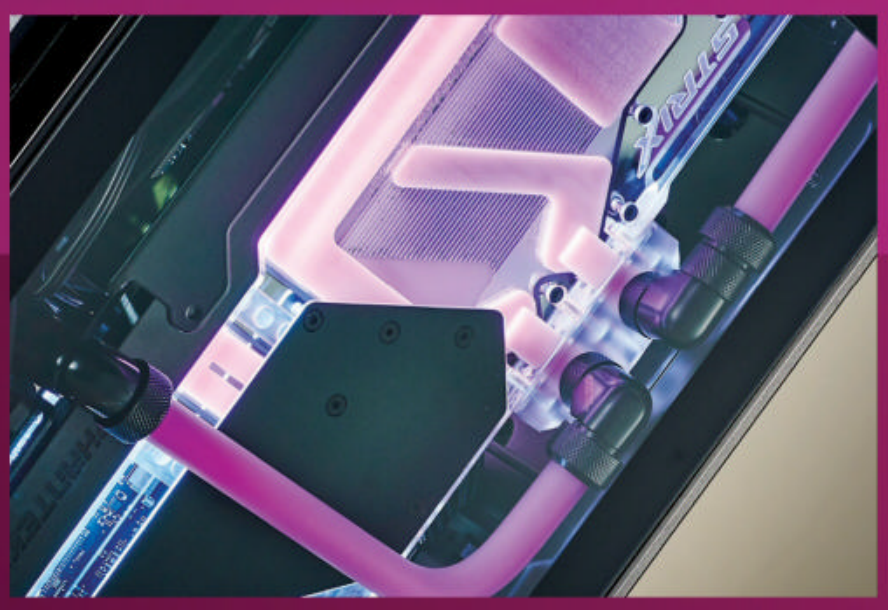
What parts to pick, tube bending techniques, and more, by Zak Storey.

INSIDE THE SUPERGUIDE

"Deciding to embark upon this advanced mode of PC building can be daunting. It requires in-depth knowledge of a vast multitude of parts, intricate experience and instinct that sometimes can't be taught. And, of course, there's plenty of room for failure"

There's nothing quite like having a custom-built liquid-cooled PC. There's something about configuring every last element of your rig that gives you an incredible feeling of satisfaction. Compare it to restoring a classic car. You know each and every component that you've bought, how it works, how you installed it, where the problems might lie, how to fix it when it goes wrong, and best of all, you know that it's going to perform better than it did before, and it's unique. Much like that restoration, with liquid cooling you become attached to your work; it suddenly has a personality, a soul, a temperament, and it's a machine that you'll remember for years to come.

Yet deciding to embark upon this advanced mode of PC building can be daunting. It requires in-depth knowledge of a vast multitude of parts, intricate experience and instinct that sometimes can't be taught. And, of course, there's plenty of room for failure, especially when mixing electricity and H2O.



That said, we recommend that every PC enthusiast and system builder tries liquid cooling at least once. A lot of these problems can be overcome with some smart planning, time, and a little knowledge. And better yet, the benefits to your system extend far further than just looks. Whether it's the extra overclocking headroom or the reduced overall noise, we believe it's well worth the investment. In fact, that last part is probably the biggest bugbear you'll find when it comes to liquid cooling your rig: cost. However, the reality is that you really don't need to spend all that much on it. You can easily convert a fully built system to liquid cooling, chilling both the GPU and the CPU with copper components, for just a little over $1,000. That's still a fair amount of cash, sure, but not quite the $2,000-plus spec lists that we often throw at our builds. Of course, with more investment comes better performance and an easier build process, but that's not always necessary, and a bare minimum loop when it comes to fittings and complex components will likely yield similar if not identical results if configured correctly.

This issue, we're going to divulge all of our liquid-cooling secrets and give you the deepest-level low-down, so you can decide whether it's worth making the commitment to build your own unique rig that's perfect for you.


DOMINATOR
DOMINATOR
PHANTEKS
acool

Parts & options

When it comes to planning your loop, the range of products available – from fittings to tubing, and radiators to reservoirs – makes for a daunting prospect for the uninitiated. So, let's break down exactly what you'll need, and what you can buy to perfect your liquid-cooling loop.

TUBING TYPES: Soft tubing

Typically manufactured from PVC, or polyvinyl chloride, soft tubing is flexible, easy to cut, affordable, and comes in a variety of different diameters and thicknesses. Although usually clear, you can find opaque colored or translucent frosted variants as well. It's easy to use and cut to length – in fact, you can get away with just using scissors if you really want – which makes building a loop with soft tubing a great choice for beginners. Downsides typically come in the form of reduced bend radii, and it also has a bad habit of leaching color over time.

There's another type of soft tubing worth mentioning here, and that's EPDM, or synthetic rubber tubing. Unlike PVC tubing, EPDM only comes in matte or gloss black. It can maintain tighter bend radii, thanks to its thicker internal walls, and also doesn't suffer from color leaching at all. This type of tubing was originally designed for industrial use, and as such, is ideal for those looking for minimal loop maintenance, or for a more grungy aesthetic for their loop.

Soft tubing is great for those starting out with liquid cooling.

Cooling theory

Most CPU cooling towers consist of small vacuum-sealed chambers containing a tiny amount of fluid. When heat is applied to this fluid, it evaporates and disperses to the extremities of the pipes. The vapor then condenses, thanks to cool air being pushed over it, then descends through a wicking material back to the source of the heat to repeat the process again.

With liquid cooling, a similar principle is applied on a grander scale. Instead of a small amount of vapor you have massive volumes of coolant, instead of convection, you have a pump, and instead of the vapor hitting the top of the heat pipe and disseminating the heat through the tower's fins, the radiator channels disperse the heat across its fins, then it's cooled by fans again.

This is why liquid cooling makes such a big difference. It's far easier to move the heat away from hot components quickly, then disperse it across a bigger surface area, cooled by more fans. An additional benefit is that as the radiators are usually located on the outer edges of the chassis, heat is expelled immediately, rather than lingering, reducing the ambient temperature around secondary components.

TUBING TYPES: Hard tubing

The most popular type of hard tubing is made from acrylic. It's a strong, clear, hard-tube, usually coming in straight lengths of about 50cm or so. It can be bent to shape using a silicon insert and a heatgun, and typically needs its edges cutting to size and chamfering off, so it can fit within its compression fittings. Like soft tubing, it can leach color over time – however, that usually only happens when it's situated in direct sunlight for long periods of time. Although it's almost always clear, you can find frosted versions as well. The only downside to acrylic tubing is that it does have a tendency to shatter when hit hard enough. Which is where PETG comes in.

PETG tubing and acrylic look almost identical, yet the two have very different material characteristics. PETG has slightly less clarity than acrylic, and additionally features a far lower melting point, making it easier to bend. The big advantage, though, is that it doesn't shatter under pressure; instead, it compresses when force is applied.

Although it requires extra skill, hard tubing looks much neater.

You can also get borosilicate glass tubing, which apart from being PH neutral and impermeable, features the highest clarity of all tubing types. Typically used in straight lines with angled extensions, it can also be bent with a blowtorch and skill. Finally, there's annealed copper tubing, which can be plated in zinc, chrome, or other metals, or powder coated. To bend this, you need a fairly heavy-duty mandrel.

Fittings

A good rule of thumb is to remember you'll need at least two basic compression fittings for each liquid-cooled component. Outside of standard fittings, there's a ton of different types out there, so let's break them down.

COMPRESSION FITTINGS

These are the main fittings for connecting tubing to hardware. They come in a variety of sizes, and vary depending on the tubing type you use. Some are for hard tubing and some for soft. As standard, on the male end of a hard tubing compression fitting comes a G1/4-inch thread and an o-ring, to stop leakage. Remove the compression cap on the female end, and you'll see another two o-rings inside the fitting. This is where you'll push the chamfered edge of your tube in and past, before sealing it with the compression cap, which features an additional o-ring. Soft tubing compression fittings are very similar. They still have a G1/4-inch thread, and an o-ring on the male side, but once the compression cap is removed, there's a metal barb beneath that the tubing slides over. Once the tubing is on the barb, the compression fitting secures on its thread and compresses the tube on to the barb.

MISCELLANEOUS FITTINGS

There's also a number of specialist fittings that you need to know about. Ball valves are an important one – they enable you to close and open a valve to allow coolant in or out (this is ideal for loop maintenance). Pass-throughs enable you to drill holes directly through a case panel, and provide a female G1/4 thread on either side. Plugs literally just plug a G1/4 port. Meanwhile, T, Y, and X junctions enable you to move coolant in multiple directions from a single point, and quick disconnects give you the option to disconnect entire lengths of tubing quickly and easily, and then rejoin them with minimal coolant loss, making them perfect for builds where you need to swap out or test hardware on a regular basis.

ANGLED FITTINGS

A branch of extension fittings, these fittings can provide dramatic angle adjustments in a very tight radius. Most of these are rotary fittings, too, meaning they can be adjusted to point in any 360-degree direction. You'll usually find 33, 45, and 90-degree angled fittings, and sometimes even twin 45-degree fittings as well (with two rotary joints to allow for more flexibility and orientations).

EXTENSION FITTINGS

Extension fittings increase the distance between the liquid-cooling hardware and the next fitting. They come in all sorts of lengths, can be daisy-chained, and can even feature male-to-male connectors to join two bits of cooling hardware together.

WATERBLOCKS

If it produces heat, there's probably a waterblock for it. That said, these are often the simplest part of speccing out your liquid-cooled build. The only thing you need to be aware of is compatibility. When it comes to a graphics card, you're going to want to make sure that the waterblock is compatible with the PCB on the card. Aftermarket graphics cards typically have custom PCB designs with different VRM locations and more, so not all reference waterblocks will fit them. Most waterblocks are designed for reference PCBs, but many manufacturers do offer additional blocks for bespoke models. Always double-check for compatibility before you buy.

The same goes for processors – although most blocks have mounting solutions for both Intel and AMD CPUs included as standard, some don't. The big exception is, of course, Threadripper, because its CPU die is far larger than that of the average chip.

Motherboard monoblocks, on the other hand, are a bit more complex. They're designed to reduce heat on the CPU's VRMs and MOSFETs, while cooling the processor at the same time. Because many motherboards feature unique layouts with regard to power delivery, these are often only provided for select motherboards within a manufacturer's range.

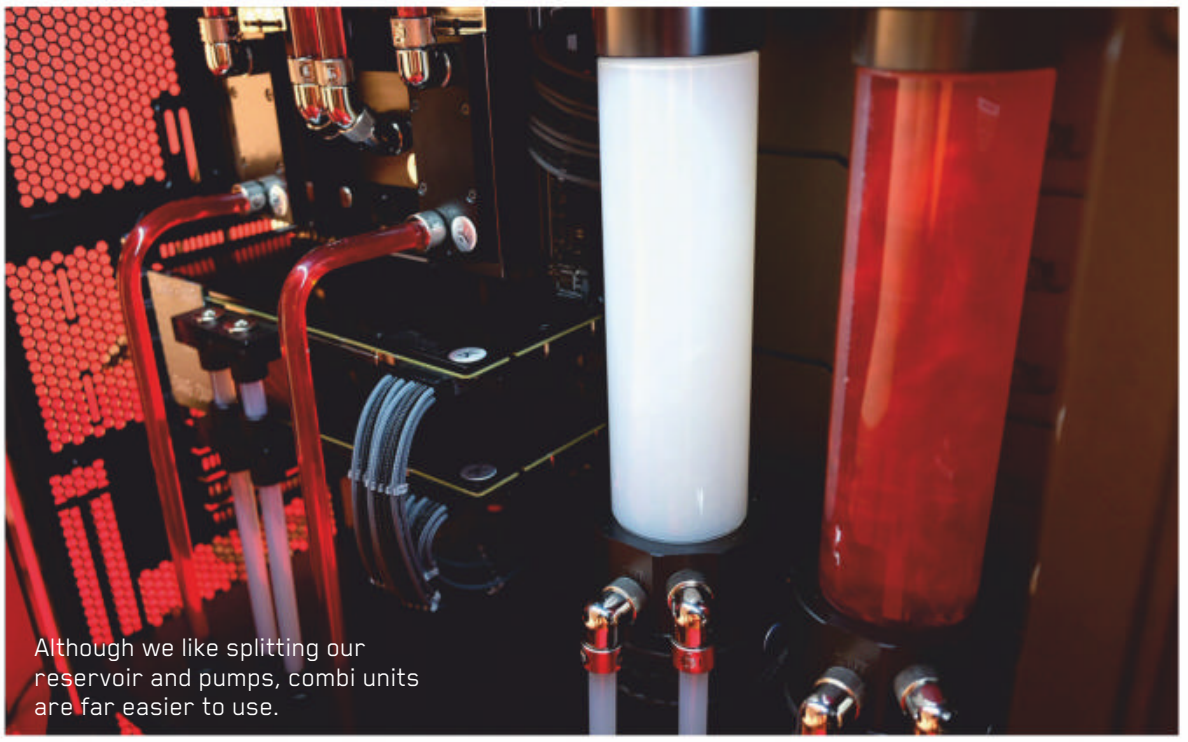
A good waterblock can really make your build shine.

Main ingredients

RESERVOIRS & PUMPS

Reservoirs come in all shapes and sizes. Most common are cylindrical tubes with ports on the bottom and top, or integrated with a pump. However, distribution plates, 5.25-inch bay reservoirs, and rectangular reservoirs are also available.

As for pumps, almost all of them are manufactured by a single company, Laing, then distributed to liquid-cooling brands, which house them in their own products. There are two main pump types, the D5 and the DDC. The D5 is a large form factor pump, ideal for liquid-cooling systems with multiple radiators, reservoirs, and waterblocks, whereas the DDC has a far smaller footprint, and is ideal for small form factor and ITX PCs.



Although we like splitting our reservoir and pumps, combi units are far easier to use.

FANS

We recommend fans with a high static pressure and a low noise rating. One of the best things about liquid cooling is it gives you a smoother way of dissipating heat by using more fans at lower RPMs.

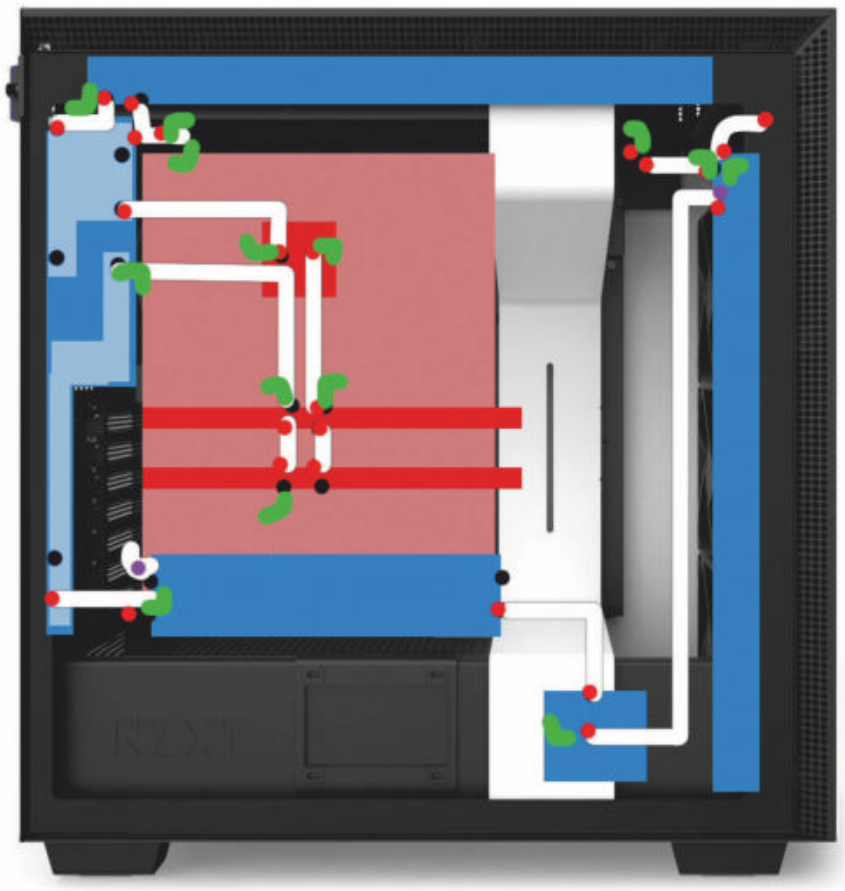
Typically, with a CPU tower, the heated vapor needs to be cooled immediately, so it can do its job again, and it spikes in temperature as soon as the CPU is under load. With liquid cooling, because there's so much coolant being pushed by the pump, the coolant has a far higher thermal capacity, giving you time to cool it down via the radiator's far larger surface area, with more fans. So, you can run more fans at lower RPMs, reducing noise, while still extracting heat from the coolant adequately to keep everything running smoothly.

For most of our liquid-cooled builds, we set the fans to 30-50 percent of their total RPM and leave them there. This is fantastic for those frustrated with loud fans or in noise-sensitive environments. Take a Corsair ML 120 Pro, for example. At max speed, it hits 37dB(A), but drop it down to 1,000rpm (half its max speed), and it only reaches 18.5dB(A) – that's the difference between a busy office and a whisper, and yet it'll still be pushing close to 2.1mmH2O, which is more than enough to cool our low fin density radiators.

RADIATORS

Radiators are the primary means for you to remove heat from your system. Most radiators come in sizes that are derivatives of either 120mm or 140mm, in the same manner that PC case fans do. So, you get 120/140mm, 240/280mm, 360/420mm, and 480/560mm radiators, going from one fan all the way up to potentially four fans per side. On top of that, they can be far thicker than a standard AIO radiator. Taking EKWB as an example, its SE (slim edition) 120mm radiators are 28mm thick – that's about the same thickness as the radiator used in the Corsair H100i. Most regular custom loop radiators are considerably thicker than that, with the average being around 40mm or so.

When it comes to radiators, there are two things to take note of: Firstly, you're going to want at least 120mm of surface area per component you want to cool (double that for overclocking), and secondly, you need to pay attention to fin density, or FPI. The higher the density, the more static pressure you need to effectively push air through it. In the case of that H100i we mentioned earlier, it has a fin density of around 21 fins per inch, compared with a 240mm super-thick XE radiator from EK, where you're looking at just 16fpi.



Preparation

PLANNING YOUR PERFECT LOOP

Now you have an understanding of all these different components, it's time to decide what kind of loop you want to build, how you're going to build it, what case you're going to use, and more.

You might already have a chassis in mind, or maybe you're keen to reuse your own – regardless, whatever you pick, we recommend it has good radiator support and strong intake air access. For a beginner, a big mid-tower case will help significantly when it comes to crafting your loop.

Something such as Fractal Design's Define R6 or the Phanteks Enthoo Evolv X are great options for rookies because they provide solid airflow and plenty of support for liquid cooling is included right off the bat.

The best thing you can do before you begin is research the chassis you have in mind. Strike up its name on Google, add "liquid cooled build" to the end of it, and see what results you get. When we plan our systems here at *APC*, we do that first, then head to **http://pcpartpicker.com** and **http://builds.gg** to check out the build logs there.

Once your case is selected, you'll want to grab a pencil and paper next, and start drafting your loop design. You could do this in Paint or Photoshop, too, but either way, you want to roughly sketch out your chassis and start planning your runs. This is also a good opportunity to figure out how many fittings you'll need. It does require a fair bit of brain power to visualise your internal layout and what angled fittings you'll need, but it's a quick and effective method to figure it all out. It's worth noting that, inevitably, your finished system won't look like your plan – you'll likely have to adapt to problems on the fly – but it gives you a good basis to work from.

MANUFACTURER CHOICES

There are numerous manufacturers that provide liquid-cooling hardware, from the sharp crisp waterblocks of EKWB to the glamorous fittings of Bitspower and the potent performance-heavy radiators of Alphacool. You can generally mix and match as you please, because most liquid-cooling hardware abides by the same standards.

However, one thing to be aware of is copper versus aluminum cooling. There are plenty of aluminum liquid-cooling products, which are usually cheaper than copper parts, but they cannot be used with copper components. If you're going aluminum, everything has to be aluminum, no exceptions. Reason being, the two metals (copper and aluminum) react with one another in the coolant (the coolant acts as an electrolyte, and galvanic corrosion occurs), leading to potential gunk build-up in the loop, and damage to the aluminum parts over time.

This can also happen depending on the type of coolant you use, because many coolants take advantage of biocides and other chemical procedures, some of which react poorly with nickel plating, so we always recommend you go with trusted coolant manufacturers.

Things to consider

When it comes to planning your loop, you should keep a few key rules in mind:

01 Make sure your pump is gravity fed. There's nothing worse than running a pump dry – you'll damage it in the short term, and kill it in the long run.

02 Think about loop maintenance. Eventually, you're going to have to change the coolant. It could be six months, it could be three years, but it's coming. Think about where your drain port is going to be and where your fill port is going to be. Typically, your drain port should be located at the lowest point of your loop, and the fill port above the res.

03 Aesthetics or performance? This next one is pivotal. By far the most effective liquid-cooling loop for pure performance is a serial one, connecting one component to another, and so on. However, you'll often find folk (ourselves included) running parallel loops. This is because they look better, but performance tends to be worse, especially with low pump speeds.

04 Compatibility. Always think about what happens if something goes wrong. This is less of an issue with soft tubing, but if you have to reseat your memory, and there's a hard tube running across the top of it, you'll have to disassemble the entire system.

Techniques & skills

Now you've got everything planned, measured the case, and ordered the parts, it's time to get on with the build. The first and most terrifying part of the process is the graphics card disassembly. This is perhaps the most dangerous part of liquid cooling. If you get it wrong, and knock off a capacitor or a memory chip, your GPU is as good as dead. And you can bet your bottom dollar few manufacturers will honor the warranty if that happens. So, where do you begin?

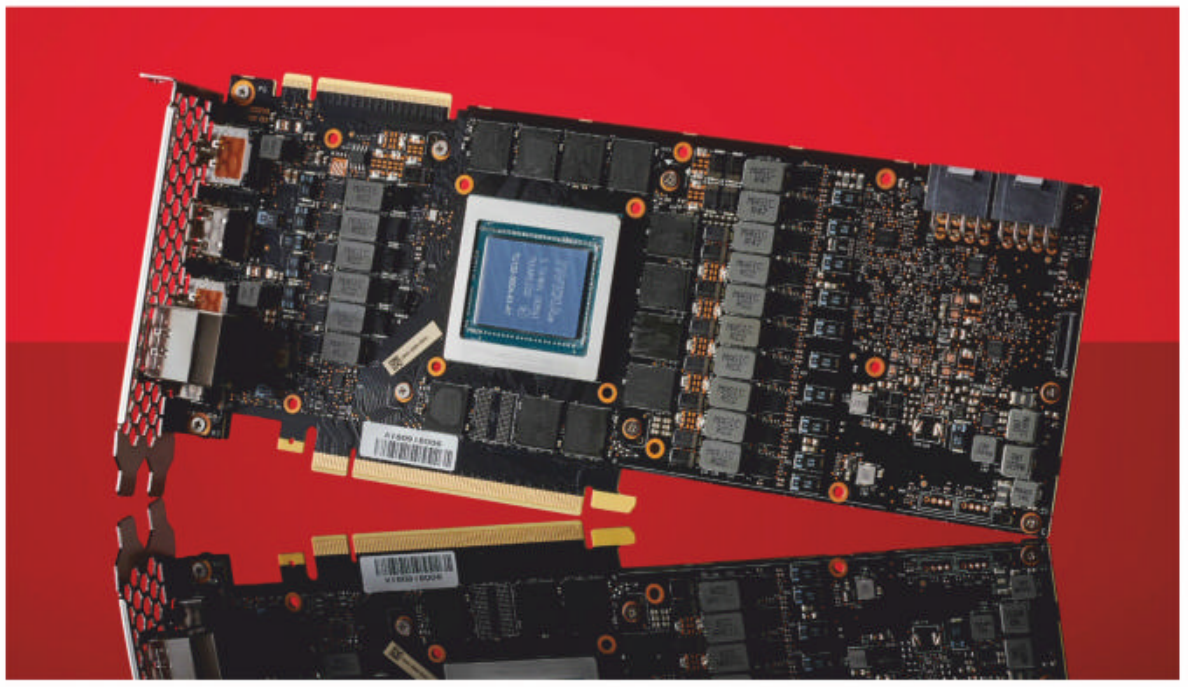
PROCESS

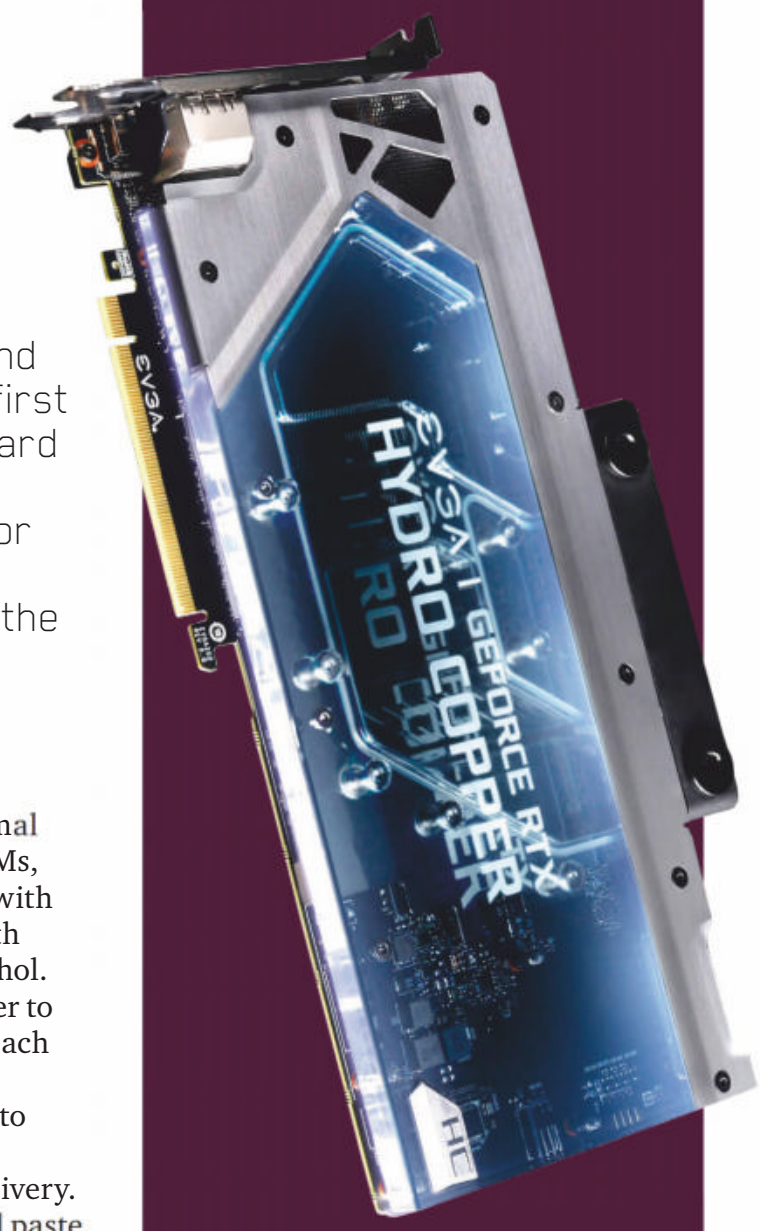
Well, you've bought your waterblock and you know it's compatible with your GPU. Now you're going to begin to strip down the graphics card. To do this, first remove the backplate – you'll find tiny Phillips head screws here, but a small precision screwdriver should do the trick. Once the backplate is off, you'll be able to work out how the rest of the card is secured. Remove all major screws, and identify where the cooler itself attaches to the PCB (there's usually one or two screws connected to the rear I/O plate as well). Be sure to detach any fan or RGB headers, and very carefully prize the two cards apart, slowly rocking it back and forward. The last thing you want to do is rip anything off. Word of advice: For those disassembling a Founders Edition graphics card, the screws underneath are 4mm or 3/8-inch hex screws – you really ought to use the correct socket to remove these; you can use pliers, but there's a higher risk of knocking off a capacitor from the rear.

With the cards prized apart, you can then remove any additional plates or support brackets on the graphics card, and then it's time to clean up the GPU itself. Remove any remaining thermal pads from the memory and the VRMs, then clean off the GPU, preferably with an alcohol wipe or a microfiber cloth coated in 99 percent isopropyl alcohol.

The next step requires you to refer to your waterblock manual, because each block has different mounting mechanisms. They usually ask you to apply a thermal pad to each of the memory chips and to the power delivery. Then it's a case of applying thermal paste to the GPU directly, before you begin the process of adding the waterblock to the card. Line the block up with the screw holes around the GPU, and carefully place the block into position. Now, secure the block around the GPU first, screwing the included screws down in a hexagonal sequence. Then it's a case of installing the remaining screws into the GPU block and you'll be good to go. One thing to note: Once the four screws surrounding the GPU are in position and the waterblock is relatively secure, if you have a backplate, now is the time to check the manual to identify which screws you need to leave out, because the backplate will need to be secured via additional threads.

"By far the scariest part of any liquid-cooled build: the GPU teardown."





Pre-blocked GPUs

If you're not sold on stripping down your pride and joy to liquid cool it, there is, thankfully, a fairly good alternative out there, although it might be a bit pricier. A lot of manufacturers now offer a pre-blocked version of their highest-end graphics cards. EVGA has its Hydro Copper line, Gigabyte has the Aorus Xtreme Waterforce, and Zotac has the ArcticStorm. All of these cards come with a warranty and often only cost $200–300 more, which, let's face it, is the price of a good waterblock anyway.

However, there's one significant drawback to all of this, and that's the fact that you can't use these cards outside of their liquid-cooled environments. All of them require you to install a full loop before you can even test that the GPU itself is functional. Now, that's an issue, because we know liquid cooling isn't an easy task, and building a loop to then have to strip it because you have a dud graphics card is going to take a considerable amount of time.

On top of that, when you're upgrading to your next rig or graphics card, it's far harder to sell a card that has a waterblock on it than one on which you can reinstall its original stock air cooler.

Tube Tips

HOW TO USE SOFT TUBING

The issue with soft tubing is less to do with the process of fitting it, and more to do with identifying how to run a length of it. It's all to do with bend tolerances. The shorter the length, and the tighter the bend you want, the more likely you are to kink it. If it kinks, coolant can't flow around the loop, temperatures sky-rocket, pressure can build up, and it can damage the components within the loop. This is why it's useful to plan the loop out beforehand, and even include a few 90-degree extension fittings here and there. A clean soft-tube build typically requires quite a few angled fittings.

That aside, how do you actually do it? First, attach your soft-tubing compression fittings to the two components you want to connect. Then remove the compression caps from both fittings, revealing the barb underneath. Now take your coil of soft tubing, and run a length of it between the two fittings. Make sure you measure from the bottom of the barbs when you do this. Next, cut off slightly more tubing than you think you need. You can always shorten a length of soft tubing later.

You can usually cut soft tubing with a good pair of scissors.

Now you're going to take the compression cap and slide it along the tube, making sure it's in the correct orientation to secure itself back on to the fitting. Next, take a pair of needle-nose pliers, insert them into the end of the tube, and then carefully stretch out the bottom of the tubing in both directions.

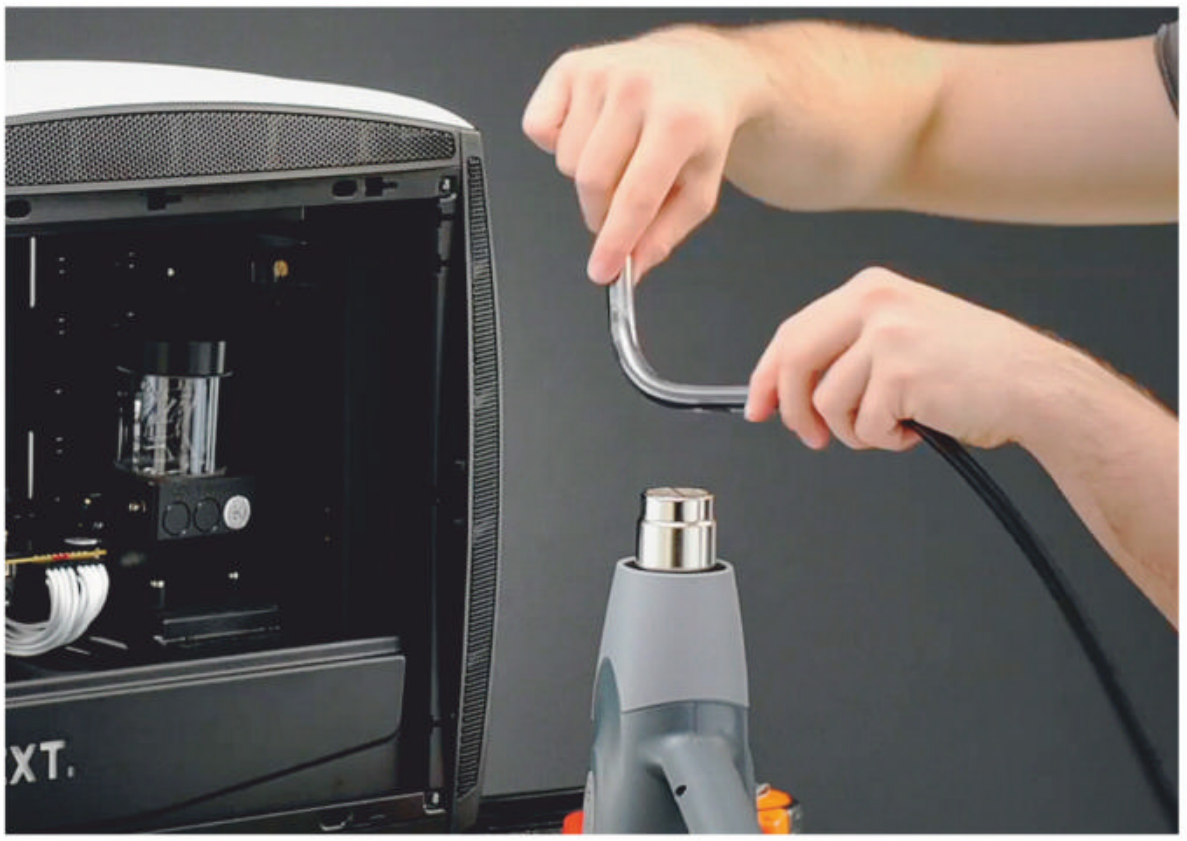
Now you can wiggle that stretched part of the tube on to the barb and past the lip of the fitting. Finally, secure the compression cap back on to the fitting, and repeat the process at the other end.

TUBE BENDING

When it comes to tube bending, we always recommend that you stick to a single 90-degree bend per length of tube. In fact, take a look at any of our custom liquid-cooled builds that we've done over the last two years, and you'll notice almost all of the runs feature single 90-degree bends. Secondly, always, always, always cut off more than you think you need. You can always reduce the length of tubing, but it's impossible to increase it without leaning on extension fittings, and that can look ugly. So, where do you begin?

Well, you're going to need a heatgun that can be placed on its back with the nozzle pointing up, a silicon tube insert that matches the ID (inner diameter) dimensions of your tubing, a hacksaw specifically designed to cut acrylic, a deburring tool to chamfer down the edges (sanding paper also works), and a vice grip to cut your tubing lengths with. Most of these you can buy as a kit from a liquid-cooling manufacturer.

Once you've gathered all that together, wet the silicon insert (having a bowl of water to hand helps here), and insert it into the tube. Then set your heatgun on a medium setting, and carefully hold the tube above it in the middle, three to four inches from the tip of the gun. Rotate the tube while moving it back and forth across the heat. This heats the entire area and helps prevent kinks forming in the tube when you perform your bend.



It's always smart to keep heating the outside edge while you perform the bend.

This next step varies depending on whether you're using PETG or acrylic, but over time, you'll notice the tube becomes more malleable where you're heating it. Once it becomes flexible enough, slowly and carefully bend it into a 90-degree angle. To do this, you can line it up with the corner of a table, a case, anything. Once you've got the angle just right, carefully lower the heated tube into your bowl of water to cool it down, then remove the silicon insert.

To fit it, remove the compression cap from the fitting – being careful not to lose the o-ring – pop the cap on the length of tube, followed by its o-ring, then push it into the compression fitting, past the two internal o-rings. Once done, move the external o-ring down to the thread, bring the cap down, and secure it in place. Repeat this process at the other end, and your first tubing run is complete.

Cool Runnings

FINAL STEPS

Now you're almost there. Your system's built, your waterblocks are in place, and you've finally got all your tubing runs nice, tight, secure, and in position. There's a few checks you need to perform before you commit any coolant to your system.

01 Double-check all your fittings have o-rings and are compressed and tight. This goes for reservoir caps as well.

02 Make sure any excess G1/4 ports – on graphics cards, pumps, reservoirs, or radiators – are sufficiently plugged with plug fittings.

03 Make sure all of your PSU power cables are unplugged from your motherboard and graphics cards, so they're not providing power and therefore heat during the priming process.

04 Make sure you have a PSU bridge attached to your power supply's 24-pin ATX cable, so you can power up the pump and fans without turning on the system. You can pick these up cheaply from most liquid-cooling stores.

05 Place paper towels underneath any point where a tubing run connects with a fitting, or a fitting connects with a thread.

06 Plug your power supply into the wall, ensuring the switch at the back of it is turned off.

Once those checks are complete, you're ready to begin filling your loop. Open your fill port (or the reservoir, if you're lazy like us), from the top, and begin filling your loop with your chosen coolant. Fill the reservoir until it's about 75 percent full. Then turn on the power supply, using the power button to the rear of the PSU. You should see and hear the pump turn on, and the coolant drain out of the reservoir and move around the loop. If you don't, try unplugging the pump's fan header from the motherboard. Once the reservoir is empty, turn off the pump, and begin the filling process again. Keep doing this until your liquid coolant is flowing nicely around the system in one continuous loop.

Now you can top off your reservoir until it's full, and we recommend you run the system for a good 24 hours to check for leaks and to make sure all the air bubbles move to your reservoir, and before plugging any hardware back in. At that point, you can top the system off once more, reconnect all your power cables, and start installing Windows.

"You should see and hear the pump turn on, and the coolant drain out of the reservoir and move around the loop. If you don't, try unplugging the pump's fan header from the motherboard."

Fittings over tubing

If you're struggling with some of the tubing runs in your build, it might be time for you to opt for a different strategy. Although hard tubing allows you to achieve far tighter bend radii than with soft tubing, there is a limit to how tight a bend you can create. Combine that with it becoming infinitely more difficult to secure a length of bent tubing the smaller it gets on either end, and sometimes it's not worth using tubing at all.

As tubing bends, it also widens at the point where you apply the pressure to form it. No matter how tight a fit that silicon insert is, you'll inevitably have a slightly flatter tube at the point of the bend than you did before the bending process. This then makes it difficult for the compression cap to freely move over the bent area. The closer that bend is to the point at which it needs to be seated into its compression fitting, the more difficult it is to push both the cap and its o-ring on to the tube beforehand, then secure down.

You're not out of options, though, because thanks to male-to-male extension fittings, you can get around these problems. For example, in our 4K Gaming Monster build we did back at the

end of 2019, the pump was located below the reservoir, underneath the power supply cover. To attach it, we used a pass-through fitting to cut through the PSU cover, followed by a male-to-male extension below, which then connected directly to the pump's inlet port. The reservoir above it was then connected by a tiny 90-degree length of bent tubing. That was particularly difficult to secure, and in hindsight and for longevity's sake, we should have just used an extension fitting to raise up a 90-degree fitting, and then connect the two fittings together with a male-to-male extension. That would reduce the risk of any unwanted bumps or knocks dislodging the tube from its o-rings and causing an unwelcome leak.

Liquid assets

WHAT TO EXPECT

Your build is finally finished, your loop is complete, and your system is up and running – what can you expect now? Well, first up, you'll notice a dramatic reduction in overall temperatures, most notably with the graphics card. GPUs are one of the areas that benefit the most from liquid cooling. An Nvidia RTX 2080 Super, which typically runs at 85 C under load, will likely plummet to the 60 C range, if not further. This is great for overclocking and for stock overclock features, such as GPU boost.

As for your CPU, this is where your mileage is likely to vary – some processors do benefit a lot, but if we're honest, you probably won't see temperatures much better than if you were to run an AIO solution instead.

And then there's the noise, or lack thereof. We always recommend you configure your fans in the BIOS, as opposed to using desktop software.

For a liquid-cooled PC, and if your loop allows it, try to aim for a fixed RPM of around 30–50 percent. You can go lower, but on the whole, that's very much the sweet spot for a noise-to-performance ratio, and regardless of temperature, you'll still have a quiet rig whether or not you're running particularly demanding applications.

IS IT WORTH IT?

The big question we always ask whenever we cover liquid cooling is whether it's worth it. We used that classic car analogy at the beginning, and it's something we want to come back to now. Theoretically, you don't need a fast car. You just don't. No matter how you argue, a lot of the time, that family sedan will get you where you need to be in the same amount of time as the dude tearing it up in his fully restored 57 Bel Air (even after he's invested a good $20,000 into it).

And the thing is, it's the same with liquid cooling a PC. Do you need to do it? Of course not. Will it improve performance? Yeah, considerably in some cases, and it'll definitely reduce noise, but it's not a deal-breaker. Does it really matter in the long run? Probably not. But that doesn't make it any less fun, or less skillful to do. Having that masterful piece of work sitting on your desk, that you built entirely, and that no other person in the world has, quietly working hard for you as you drop in and out of load, is so satisfying.

Full Liquid-cooling kits

Alternately, if you want to save even more cash, many manufacturers offer fully equipped kits, with everything you need to get started with your first loop. Now, we know we're highlighting EKWB a lot here, but it's just an easy example to use. The company offers two kits: a full copper setup for a 360mm radiator, waterblock, and CPU loop, which would set you back around $650, or you could plump for the EK Fluid Gaming A360G aluminum kit instead, for around $370.

TOTAL COST

Can you do this on a budget? That depends on what your budget is. Liquid cooling is usually reserved for high-end systems. That's not to say you can't cool an Intel Core i5 or an Nvidia RTX 2070, but you'll see the most benefit on higher-end components, because this is usually where thermal limits come into play. At the lower end of the hardware spectrum, you're often better off investing that $1,000 into a more powerful processor or graphics card, depending on what you need.

With that small caveat out of the way, let's take a look at what you could do to build your own more affordable liquid-cooling loop. As an example, our theoretical system here is going to use an AMD Ryzen 7 3700X and an Nvidia GeForce RTX 2080 Super, and be housed inside the Phanteks Enthoo Evolv X chassis. So, we know we've got plenty of support for 360mm radiators, and good clearance internally to mount our hardware in a multitude of ways, and we can add to it later if need be. We would use a pump/reservoir combo to reduce the overall cost, and opt for ZMT tubing to give it a clean, industrial look. ■

"You'll see the most benefit on higher-end components, because this is usually where thermal limits come into play.

BESPOKE LOOP

TYPE	PRODUCT NAME	PRICE
CPU BLOCK	EK-QUANTUM VELOCITY AMD COPPER + ACETAL	$135
GPU BLOCK	EK-VECTGOR RTX 2080 RGB NICKEL + ACETAL	$299
PUMP/RES COMBI	EK-XRES 100 DDC MX 3.1 PWM	$125
RADIATOR	EK-COOLSTREAM CLASSIC SE 360	$115
FANS	3X EK-VARDAR F4-120ER 2,200RPM	$130
FITTINGS	8X EK-STC CLASSIC 10/16 BLACK	$128
TUBING	3M EK-TUBE ZMT MATTE BLACK 15.9/9.5MM	$33
COOLANT	1X EK CRYOFUEL BLOOD RED (PREMIX 1,000ML)	$28
TOTAL		$993

System News

Mark Williams explains why Western Digital customers have been seeing Red.

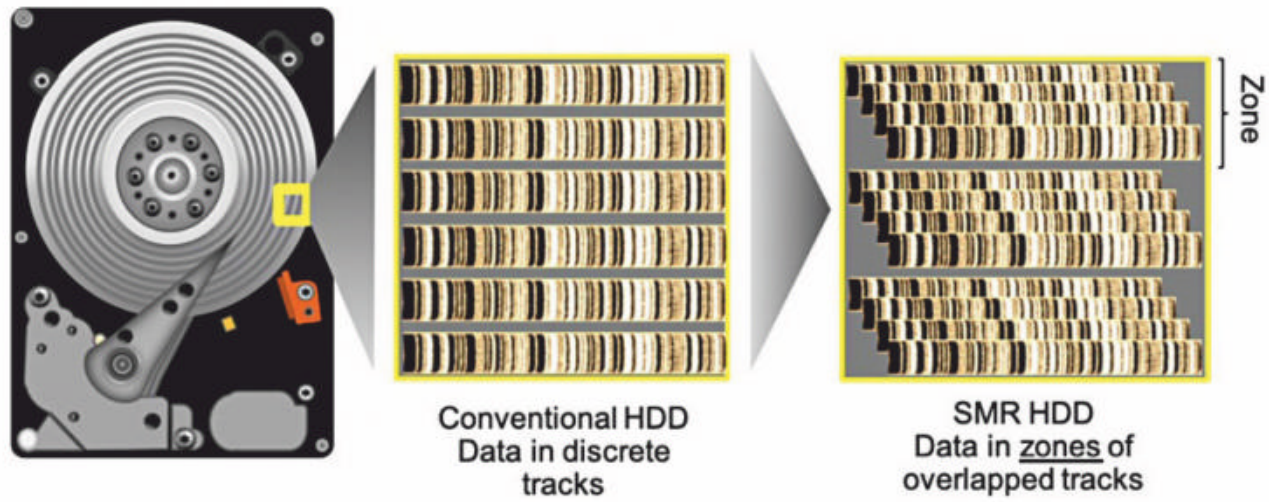
When purchasing a product, you expect to get what you pay for. What is claimed on the packaging is what the product should do.

In the world of hard drives things are usually straightforward when deciding on what to purchase. Choose the capacity you want, then pick from a drive range optimised for the intended application; like use in consumer machines (where price and power consumption are of importance), Network Attached Storage arrays or file servers (where RAID compatibility and vibration mitigations are important), or for a server where capacity, RAID compatibility and performance are all required along with solid reliability (large Mean Time Between Failure ratings).

All this has been quite straight forward until recently, when Western Digital came under fire from users claiming they were seeing evidence that some of Western Digital's Red range of hard drives were failing to install or resilver into arrays. The very thing Red drives are marketed towards, they were failing at.

Users began suspecting that these troublesome drives were using SMR (Shingled Magnetic Recording) as opposed to the typical CMR (Conventional Magnetic Recording) due to the poor random write speeds they're witnessing with them.

CMR is straight forward in its recording method, in that it writes magnetic tracks next to each other on the platter one after the other, meaning there's no performance hit going from one to the next. SMR on the other hand writes to tracks that overlap part of the previously written track. This allows for much higher densities to be achieved as tracks are packed closer together making for a cheaper manufacturing price per gigabyte, but the trade-off is that it's terrible when it comes to random write performance, which RAID and ZFS RAIDZ arrays produce a lot of as they balance data, metadata and parity information across the array.



SMR disks track organization

PIC: Blocks and Files.

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

Western Digital remained adamant that none of its Red range used SMR, but as more users came across these issues, and simple random write benchmarks showing the troublesome Red drives having the same random write performance curves as officially stated SMR drives, Western Digital capitulated and admitted that some Red drives were indeed using SMR.

SMR in some respects resembles SSD blocks in that to re-write in one track several tracks must be read into memory altered then all written back again to the affected overlapping tracks. After an intense random write command, the drive will typically need a TRIM cycle to shuffle data around to keep performance optimised for the next write. In consumer use cases that's ok as they usually produce bursty workloads with long idle times in between where the drive can reorganise itself. In RAID arrays the random writes can be quite frequent, not giving the drive time to catch up with the house keeping it needs to do internally.

Western Digital said "If you are encountering performance that is not what you expected, please consider our products designed for intensive workloads. These may include our WD Red Pro or WD Gold drives, or perhaps an Ultrastar drive. If you have purchased a WD Red drive, please call our customer care if you are experiencing performance or any other technical issues. We will have options for you. We are here to help."

Western Digital's Red drives of capacities 2TB though 6TB inclusive and with model numbers ending in EFAX are the problematic SMR drives. If you're thinking of buying one, do consider the ramifications first.

Seagate and Toshiba to a lesser extent have also been implicated, with Seagate admitting SMR is used in some Barracuda consumer drives (models ending in DM008, DM004 and DM000), but noted all of its RAID/NAS focused Iron Wolf series of drives use CMR. Toshiba also admitted that SMR appears in its P300 series of drives which are also consumer focused and shouldn't be used for NAS/RAID setup anyway.

SMR drives are completely fine for consumer workloads for mass storage, don't let this issue scare you away from them. If random writes are of concern you should probably be looking at an SSD anyway, but if you're looking to create/repair a RAID or ZFS array using any of these drives you'd be wise to look at an alternative and save yourself some pain. ■

"Users began suspecting that these troublesome drives were using SMR (Shingled Magnetic Recording) as opposed to the typical CMR (Conventional Magnetic Recording) due to the poor random write speeds they're witnessing with them."

Market snapshot

A sampling of PC systems available this month.

$1,308, tinyurl.com/APC482PLE

PLE Computers Creative Cube

This entry-level system wouldn't look out of place in any loungeroom as a media PC. While capable of gaming it won't be blowing your socks away, but it'll do an admirable job at 1080p thanks to the GTX 1650 Super. The CPU will be the main bottleneck for games and heavier tasks, particularly with the single stick of slow RAM, denying dual channel memory access. Consider choosing a dual module 3200MHz kit if gaming is on the cards. The A320 motherboard will limit upgrade options both for connectivity and processor, but all 3000 series CPUs are supported so if media transcoding or a home media server takes your fancy, there's still plenty of room to move.

CPU: AMD Ryzen 3 3200G, **COOLER:** OEM, **MOTHERBOARD:** Asus Prime A320M-E, **GRAPHICS:** ASUS GeForce GTX1650 Super Phoenix OC, **MEMORY:** GeIL 16GB Single DDR4 Pristine C19 2666MHz, **STORAGE:** WD Green 240GB M.2 SSD, WD Blue 1TB HDD, **POWER SUPPLY:** Silverstone Essential Series 550W, **CASE:** Jonsbo V4 Silver

$3,599, tinyurl.com/APC482MWV

Mwave S605i Gaming PC

For the gamer that wants it all but isn't crazy enough to drop $5,000+ for the best of everything, this is where it's at. The i7 9700K sits near enough to the top in most gaming charts to not be an issue at all if you're after 144Hz+ gaming. Particularly if you aren't afraid of tinkering with overclocking, which the 360mm AIO cooler will go a long way towards giving you a good experience. Combined with the RTX 2080 Super you'll be encroaching on RTX 2080 Ti levels of performance too. The 1TB NVMe SSD is perfect for all your gaming library installs too.

CPU: Intel Core i7 9700KF, **COOLER**: Cooler Master MasterLiquid ML360R ARGB AIO, **MOTHERBOARD:** MSI MPG Z390 Gaming Edge AC, **GRAPHICS:** Gigabyte GeForce RTX 2080 Super Gaming OC V2 8GB, **MEMORY:** Thermaltake ToughRAM RGB 16GB DDR4 3200MHz, **STORAGE:** Crucial P1 1TB NVMe M.2 PCIe 3D SSD, Seagate 2TB HDD, **POWER SUPPLY:** Unspecified, **CASE:** Cooler Master Masterbox MB530P

$2,999, tinyurl.com/APC482UMT

Umart Malachor

Looking the part as much as performing it, the Malachor from Umart is for serious gamers looking for a high mid-tier system targeting 1440p gaming. The RX 5700XT will let this system belt out RTX 2070 levels of performance. Oodles of RGB fans, a nice water cooler, and RGB memory help the system shine – literally. The Ryzen 3600X typically isn't worth the extra money over the base 3600 for around a 2% performance gain, so there'll be a price premium here. This system seems to be overpriced by around $150-$200. Ignoring how good this system is otherwise, unless you can haggle the price down to around $2,800 this might be one to pass over.

CPU: AMD Ryzen 5 3600X, **COOLER:** Cooler Master MasterLiquid ML240R, **MOTHERBOARD:** MSI MPG X570 Gaming Edge WiFi, **GRAPHICS:** MSI Radeon RX 5700 XT Gaming X 8GB, **MEMORY:** G.Skill 16GB Trident Z Neo 3000MHz RGB, **STORAGE:** Samsung 250GB 970 EVO Plus SSD, 2TB HDD, **POWER SUPPLY:** SilverStone ST65F-GS 650W, **CASE:** Azza Apollo 430

$1,599, tinyurl.com/APC482PCC

PC Case Gear Airflow 570

This system does a good job of maximising performance at a low price. The Ryzen 5 1600 AF is completely unbeatable in this category, serving up basically Ryzen 5 2600 levels of performance at the same price as an entry level Ryzen 3 3100. Mated with a B450 this will allow you to upgrade the CPU to anything from the Ryzen 2000 series through future 4000 series CPUs or APUs. The graphics card is awfully long in the tooth, but given the prices of cards these days, it still has a place at the entry level. Expect solid 1080p gaming with any esports or non-triple-A game title.

CPU: AMD Ryzen 5 1600 AF, **COOLER:** OEM, **MOTHERBOARD:** Gigabyte B450M-S2H, **GRAPHICS:** Gigabyte Radeon RX 570 Gaming 4GB, **MEMORY:** Team T-Force Dark Z 16GB 3200MHz CL16 DDR4, **STORAGE:** Kingston A400 2.5in SATA SSD 240GB, Seagate Barracuda 2TB HDD, **POWER SUPPLY:** Phanteks PH-P550GF 550W, **CASE:** Phanteks Eclipse P300A RGB Mesh Edition

BLUEPRINTS

VALUE- AND PERFORMANCE-DRIVEN HYPOTHETICAL BUILDS

PC BUILDER

Budget

Saving some cash.

In order to save a bit of cash on this build, we cut back from the Asrock B450 motherboard we had been using to a B450M offering from MSI. For the unaware, the main difference between B450M and B450 is the inclusion of DisplayPort connectivity on B450 boards, as opposed to DVI-D on B450M boards. Since we're using a discrete GPU, though, it won't be a problem. A price hike on the Ryzen 5 2600 and a sale on the newer Ryzen 5 3600 encouraged us to upgrade the CPU, bringing up this system's overall performance with faster cores and the same Wraith Stealth stock cooler. GTX 1660 Super cards are no longer on sale, so we've switched to the still-affordable MSI model. Lastly, we've returned to the super-cheap Adata SU650 SATA drive, since the Patriot drive we had been using is no longer on sale at the time of writing.

"A price hike on the Ryzen 5 2600 and a sale on the newer Ryzen 5 3600 encouraged us to upgrade the CPU."

PART		PRICE
CASE	BITFENIX NOVA TG	$75
PSU	EVGA 400 N1 400W	$94
M/BOARD	MSI PRO B450M PRO-M2 MAX NEW	$129
CPU	AMD RYZEN 5 3600 NEW	$299
GPU	MSI GEFORCE GTX 1660 SUPER 6GB NEW	$469
RAM	16GB (2X 8GB) TEAM T-FORCE VULCAN Z @ 3,000MHZ	$130
SSD	120GB ADATA SU650 T 2.5" SATA III NEW	$56
HDD	1TB WESTERN DIGITAL RE3 WD1002FBYS NEW	$106
OS	UBUNTU DESKTOP LINUX 18.04.3 LTS 64-BIT	$0
PRICE:		$1,398

Mid-range

Good news for Team Blue fans.

The Core i5-9600K has dropped in price, bringing it to the very reasonable price of $349. In fact, that's the best value we've seen any mid-range Intel chip go for in recent months, so snap it up. We upgraded the motherboard this month, swapping from the previous Asrock board to the slightly more full-featured Gigabyte Z390 Gaming X. The MSI model of the Radeon RX 5700 8GB remains the cheapest option at the time of writing, so we stuck with that. We did, however, swap out the M.2 SSD to Western Digital's 500GB SN750 from its WD Black range, a high-speed gaming drive that kept our price on balance. Lastly, the Corsair PSU we had been using leapt up in price, so we switched it for a more affordable 550W offering from Cooler Master, keeping that 80+ Bronze seal of approval.

"The MSI model of the Radeon RX 5700 8GB remains the cheapest option at the time of writing, so we stuck with that."

PART		PRICE
CASE	FRACTAL DESIGN MESHIFY C	$189
PSU	550W COOLER MASTER MWE SILENCIO FAN 80+ BRONZE NEW	$89
M/BOARD	GIGABYTE Z390 GAMING X NEW	$279
CPU	INTEL CORE I5-9600K	$349
COOLER	CORSAIR A500 DUAL FAN	$159
GPU	MSI RADEON RX 5700 8GB	$599
RAM	16GB (2X 8GB) TEAM T-FORCE VULCAN Z @ 3,000MH	$130
SSD	500GB WESTERN DIGITAL WD BLACK SN750 M.2 PCIE NEW	$168
HDD	1TB WESTERN DIGITAL RE3 WD1002FBYS NEW	$106
OS	WINDOWS 10 HOME 64-BIT OEM	$140
PRICE:		$2,208

Turbo

Disaster strikes.

We're forced to throw a load of cash at the Turbo build. EVGA's sale on the SuperNOVA PSUs has come to a close, so we're shifting over to Nzxt's E850, keeping our system wattage the same but adding nifty features like silent running under 100W and onboard DSP. The Nzxt PSU might be expensive, but it also comes with a 10-year warranty, so it's worth the price.

Something strange is happening with TR4 motherboards, too. Between COVID-19 affecting supply and production, online retailers like Amazon diverting resources to essential deliveries, and (possibly?) an uptick in PC-building at home, Threadripper board prices have risen, and the humble Asrock X399 Phantom Gaming 6 motherboard we had been using is out of stock. We've made the change to Asrock's X399 Taichi. However, the pandemic apparently hasn't affected Threadripper stocks.

The EVGA CLC 360 is becoming scarce, but is still available and the pricing is good, so it stays. We've gone down to two fans with the awesome value Enermax Liqtech II 280, although these are larger 140mm units than the three 120mm fans attached to the CLC 360. We swapped our 2080 Super over to a Gigabyte model to keep price rises in check, but we did still see an overall price hike on this build. Here's hoping next month brings some good sales.

PART		PRICE
CASE	NZXT H700I	**$217**
PSU	850W NZXT E850 80+ GOLD **NEW**	**$195**
M/BOARD	ASROCK X399 TAICHI STR4 **NEW**	**$569**
CPU	AMD THREADRIPPER 2950X	**$1,099**
COOLER	EVGA CLC 360	**$179**
GPU	GIGABYTE GEFORCE RTX 2080 SUPER WINDFORCE OC 8GB **NEW**	**$1,399**
RAM	32GB (2X 16GB) G.SKILL TRIDENTZ RGB @ 3,600MHZ	**$420**
SSD	1TB SEAGATE BARRACUDA 510 M.2 PCIE SSD	**$345**
HDD	2X 3TB SEAGATE BARRACUDA COMPUTE	**$435**
OS	WINDOWS 10 HOME 64-BIT OEM	**$140**
PRICE:		**$4,998**

PC MASTERCLASS

A PC PROJECT BUILD WITH A PURPOSE

BUILD IT

Purple Haze

Zak Storey builds the perfect 1440p gaming PC.

When a new cooler comes out from a manufacturer, it's not often met with much fanfare. These launches, especially in the tech journalism world, happen frequently, and usually only warrant a solitary news post on the likes of *Tom's Hardware*. Even then they're not likely to garner much in the way of traffic. However, when it comes to Nzxt, the company has a bit of a reputation for breaking the rules on what we've come to expect from new product launches. You can see this in its cases. Go back to 2010, and its chassis stack was fairly mediocre. Fast forward a few years, and you get innovations like the S510 Elite, the Manta, the H700 series, to the point where the company has dramatically ascended through the ranks to become a top-tier brand.

ZAK STOREY
Zak likes to unwind by tidying his cables.

"When it comes to Nzxt, the company has a bit of a reputation for breaking the rules on what we've come to expect from new product launches."

Perhaps even more impressive than its cases is the company's cooler design, specifically its Kraken series AIOs. The first gen was very much like the rest of the Asetek AIOs out there – pretty mediocre, some light branding, and a bit of RGB. The second gen came with its own infinity mirror and some stellar lighting effects thanks to Nzxt's own CAM software suite, and that was it. In 2019, though, we witnessed the launch of its third-gen Kraken-series coolers, most notably the new Z range. These flagship coolers come with one heck of a premium price point, but also with a fully integrated 2.36-inch LCD digital display.

In fact, it's such an impressive part that we decided to theme an entire build around it. So the task here was simple; combine a truck-load of Nzxt parts with a $4,000(ish) budget, and aim to hit that 60fps sweet spot at 1440p.

Best laid plans…

… of mice and men often go awry. When we originally set out to do this build we wanted to see what we could do with the Nvidia GeForce RTX 2070 – not the Super variant but the standard 70 version. Pairing it with a Ryzen 5 3600X seemed like a good mid-range choice, and as most of our testing is done with Intel processors with GPUs, this pairing made for an interesting case study. The logic behind picking the standard 2070 was that it should, by all visible measures, be considerably cheaper than the RTX 2070 Super, as it packs about 10 to 15 percent less performance overall and has been out for far longer.

We reached out to manufacturers to request a GPU, went ahead and built the entire system, and photographed it all, only to then realise that the RTX 2070 was coming in at more than the reference Founder's Edition RTX 2070 Super. We fell prey to that old adage – never assume, because it makes an a… Well you know the rest. Anyway, we can only guess that this price jump is down to a lack of stock or Nvidia phasing the original RTX cards out of existence. So we went back to the drawing board, rebooked photography, and grabbed that 2070 Super instead. That's not necessarily a bad thing – the Founder's Edition is still a classy card, and it complements this build quite well.

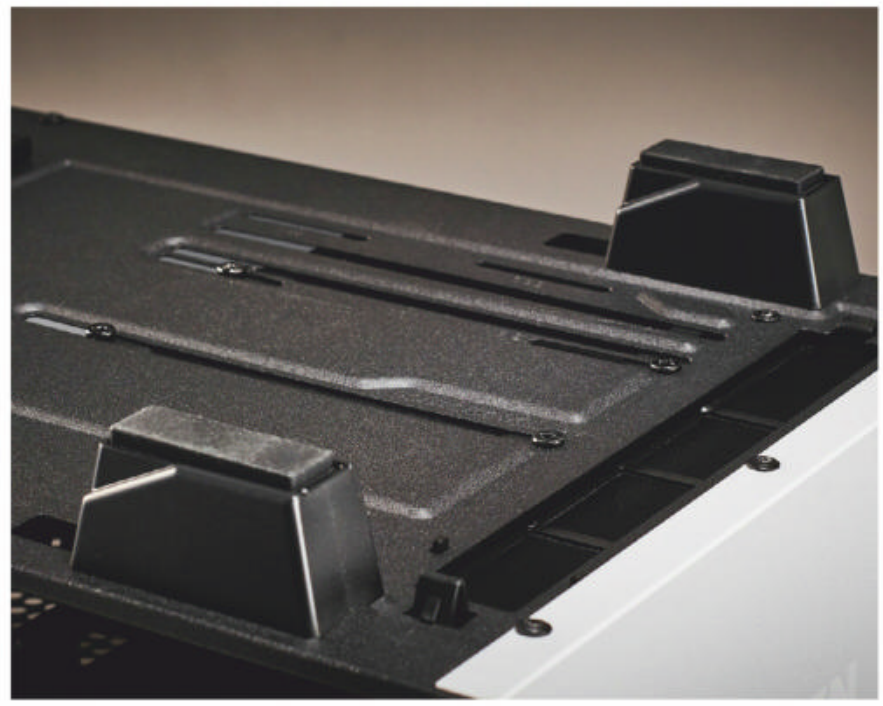
As for other components, this rig was all about style and showcasing that stellar cooler. To that end we opted to take Nzxt up on its offer of an H510 Elite case too. Its crisp clean glass panels and solid internal design makes building a mid-range system within it fairly easy, and it looks fantastic to boot. On top of that, we threw in a PCIe 4.0 M.2 SSD from Corsair, 32GB of G.Skill Trident Z Neo memory for some more RGB elements, and left it at that.

PART		PRICE
CASE	NZXT H510 ELITE	$279
MOTHER-BOARD	MSI MEG X570 UNIFY	$539
CPU	AMD RYZEN 5 3600X	$365
GPU	NVIDIA GEFORCE RTX 2070 SUPER	$879
MEMORY	32GB (4X8GB) G.SKILL TRIDENT Z NEO @ 3600	$409
PSU	750W NZXT C750 MODULAR 80+ GOLD	$175
STORAGE 1	500GB CORSAIR FORCE MP600 M.2 PCIE 4.0 SSD	$259
STORAGE 2	1TB CRUCIAL P1 M.2 PCIE 3.0 SSD	$180
CPU COOLER	NZXT KRAKEN Z63 280MM AIO	$449
140MM FANS	1X NZXT AER RGB 2	$39
OS	WINDOWS 10 HOME 64-BIT	$140
TOTAL		**$3,713**

"The logic behind picking the standard 2070 was that it should, by all visible measures, be considerably cheaper than the RTX 2070 Super, as it packs about 10 to 15 percent less performance overall and has been out for far longer."

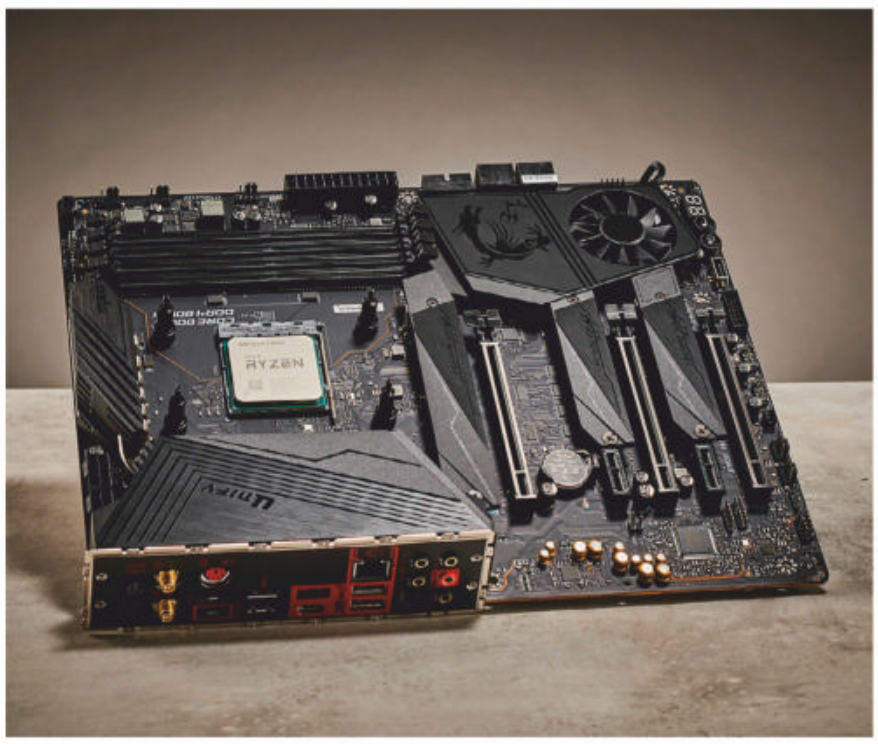
01 CASE UNBOXED

We've seen a lot of striking case launches over the last few years, and the Nzxt H510 Elite is up there with the best of them. Although it doesn't have the airflow grunt of some of its competitors, there's no arguing with the fact the style it exudes from those tempered-glass side panels, integrated with RGB fans, is impressive. Straight out of the box, it's a fairly clean affair. There's not too much we're going to have to adjust at first glance. The main issue is our rear-most fan, being of the non-RGB variety. That really doesn't make a whole lot of sense, especially given how you've got those two Aer RGB 2 fans in the front anyway. We know it's to lower costs, but this is a premium chassis with a premium price point already, so just throw in the extra rear fan Nzxt.



02 HDD CADDY REMOVED

There's been a number of hardware changes that's made system-building easier over the years, but none as effective as the rise of M.2 drives. Replacing the 3.5-inch and 2.5-inch form factors, if your motherboard has the slots for them, you can build an entire system without a hard drive in sight, which means fewer cables. There's now a range of fairly affordable SATA and PCIe drives available in the form factor too. Your best bet? 500GB PCIe 4.0 drive for your OS, 1-2TB PCIe 3.0 drive for additional storage Back to the case, and getting rid of the hard drive caddy is easy. Remove the four Phillips screws from the bottom of the chassis, plus the one attaching it to the motherboard tray, and you can easily slide the caddy out.



03 STANDOFF PREP

Now those are some meaty standoff screws for the cooler, that's for sure. We've taken the opportunity to fit them before the motherboard goes in the chassis here. It just makes things easier. Most cases nowadays support large enough motherboard tray cutouts that you can do this inside, but it can be annoying, so it's best to do it outside of the chassis. MSI's Unify motherboard is an area where we splurged a bit too much, perhaps. It's a sleek black board, with no RGB, and a ton of connectivity on top, but it's not the prettiest motherboard. It doesn't have quite the same style as some of Gigabyte or Asus's offerings.

04 MOTHERBOARD INSTALL

With the standoffs prepared and the Ryzen 5 3600X in place, we've gone ahead and installed the motherboard into the system. This typically should be your first step – even with liquid-cooling builds, it's almost always the motherboard that goes in at the beginning. Then you can start looking at cable runs and where to install other hardware. It's a bit of a tight fit in the H510 Elite, but nothing really too worrying. If you do have trouble, you can remove that cable bar temporarily and reinstall it after the motherboard is in position. It's also handy if you're trying to route troublesome cables. Here we're also installing the M.2 drives underneath the two heatsinks on the motherboard, placing the Corsair Force MP600 at the top.

05 CABLE MANAGEMENT PREP

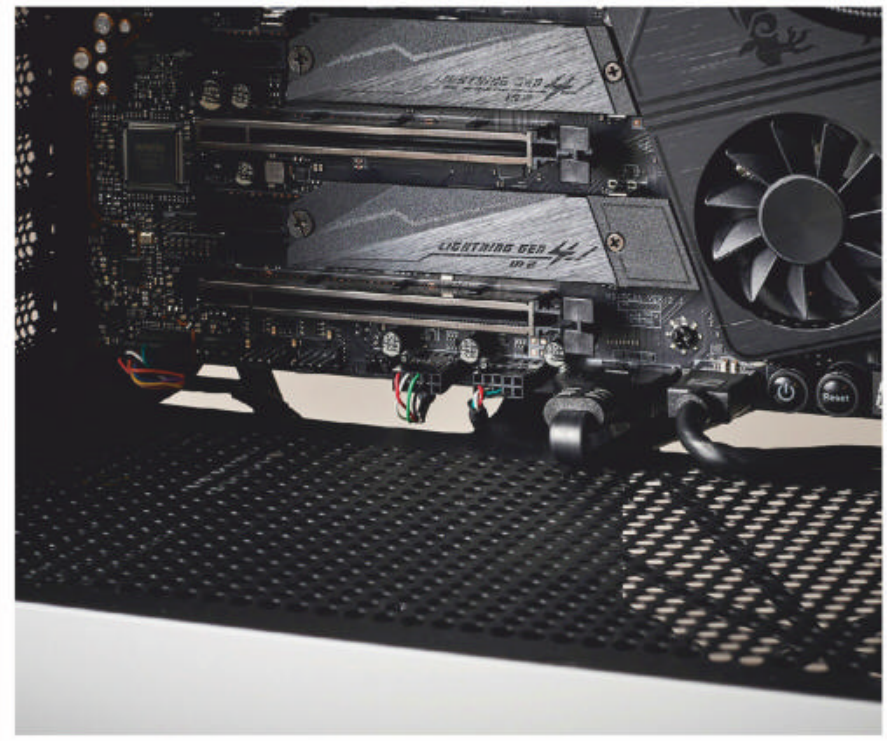
Nzxt has always done well with cable management in the rear of its cases. You can see the dedicated channels designed to help route that ATX cable to where it needs to go, the channels at the top of the motherboard tray to direct fan cables to the Nzxt CAM controller, and the Velcro straps littered around too. You can also see just how much space we get by removing that hard drive caddy from the bottom of the chassis. That's a big deal, especially with non-modular power supplies, but even with modular ones you'll often have excess cable. There's two more SSD caddies in the back as well. With Nzxt's cable management you can remove all of these parts – the cable routing, the SSD caddies, everything – by removing the Phillips head screws.

06 INSTALLING THE KRAKEN

The H510 Elite features a front-mounted radiator bracket. It's removable from inside the chassis. The reason for this is that you can't actually remove the front tempered-glass panel. So instead you remove the bracket, then install the radiator with the fans attached on the interior side of the bracket. This'll give you plenty of airflow. Along the rear side panel, there's perforations cut out, running about an inch thick down the front of it, to provide ample access to air. One thing that does disappoint us is that Nzxt hasn't found a solution for driving high static pressure with its Aer fans just yet. These 140mm variants only provide up to 1.52mm-H2O at full load – far less than the likes of Corsair's ML Pros or Noctua's NF-F12s.

07 SECURING THE BLOCK

With the radiator bracket reinstalled and the fan cables carefully threaded through into the rear of the case, it's time to install the block itself, and it is seriously big. That's not that surprising really. You've got that two-inch screen, a pump, a water block, a tiny reservoir, and the componentry to display all the digital statistics. It's worth noting, when installing your waterblocks, to always double-check that the tubing won't come into contact with your memory DIMMs. If they do, you can get around it by moving the memory to the two alternative channels, or in the case of having four sticks like our build. We recommend that you install those first, then install the CPU block afterwards. It'll put some pressure on the top of the stick, but otherwise you should be fine.



08 INTERNAL I/O

With that out of the way we can begin to install the front panel headers and necessary USB headers onto the motherboard. The H510 Elite comes with USB Type C, as well as USB 3.0 headers for its I/O. On top of that you'll also need to install the two USB 2.0 internal headers – one for the Kraken Z, and the other for Nzxt's CAM fan and RGB controller. We're even including the HD audio passthrough on the far left there. That's not something we typically recommend you use. More often than not, you'll find case manufacturers skimp out on the insulation for the cable, and audio quality suffers in comparison to just plugging your audio hardware into the rear of the motherboard.

09 NZXT'S C750 PSU

We're trying out one of Nzxt's C750 PSUs for this build. It's a newly released budget power supply, comes in at around $175, and it features a modular interface and fairly impressive cable sleeving. It's not individual sleeving, but it still looks very clean. 750W is more than enough for any modern-day system. In fact this is probably enough to actually run two RTX 2080s in SLI if you wanted to.

10 FAN WOES

We received an additional Aer fan to install into the H510 Elite, just to boost the internal lighting a bit and exhaust hot air through the roof. It works well, but one thing to note is that it's a bit finicky with some motherboards. To get it installed we have to fit all of the top cables first, including the CPU power, and then gently force the fan into position to line its mounting holes up with the case itself. Once that's done, it is simply a case of plugging it into the Nzxt CAM controller, so we can take advantage of all of that RGB. You'll notice that we're installing the G.Skill Trident Z NEO memory as well. That will add more pop to the overall build, and it is considerably brighter than the first edition RGB memory G.Skill released back in 2016.

11 GPU INSTALLATION

And here we have the RTX 2070 in all its glory. Installation is a fairly seamless experience. Simply remove the retention bracket that secures the expansion slots (two thumbscrews do the trick), then remove the covers you need to, slot the card in, secure it with those same screws, and you're good to go. We have two different options in how to install the PCIe power for this one. The most obvious route is to go through the cable cutout in the floor of the PSU cover, and then run straight up. We're taking the second option. It's a bit "old school", but we've decided to run the cable by the side of the cable tidy bar, and tuck it between the two. This way it stays tucked out of the way and is less obvious than running straight up to the graphics card.

12 DISPLAY FOR DAYS

And there we have it, our complete build. With a quick install of Windows 10 and some RGB software installation, we have this rig running in a nice purple-and-white gradient effect. The CAM software is fairly intuitive, with a responsive UI that works well together. You get a whole swathe of different presets to use with the Kraken Z's display, from GIFs to varying temperature-monitoring setups. You can also do graphics card monitoring, as well as a few other system components. We particularly like how these settings aren't locked to colors either, so if you want to set it to go from white to purple, you can do. You can spot the G.Skill memory in the background, showcasing its smooth RGB gradient. It looks cleaner than the older Trident Z kits when illuminated. You do need to control that with G.Skill's own software suite though, rather than through motherboard control.

13 ACHILLES' HEEL?

There's no denying that the Aer RGB fans look stellar with those light-diffusing rings running around them, but they are the biggest potential Achilles' heel to this whole build. That lack of static pressure could be a game-ruiner, especially during the hotter seasons. If you've not got air-con you might be in for a world of hurt. If you're looking for an alternative fan that has more static pressure grunt but without losing some of that RGB class, we'd recommend that you take a look at EKWB's latest Vardar X3M fans. They're only available in 120mm variants at the moment, but they still feature an epic level of RGB pizazz, and better yet can pump out an impressive 2.75mm H2O under full load.

14 BUILD COMPLETE

Nvidia's latest GeForce RTX series of cards gets a lot of flack for its new cooler design. While it is true that those twin open-air fans aren't quite as good in confined spaces as a blower-style cooler is, there's something to be said for the overall aesthetic appeal. We particularly enjoy how the purple light diffused by the various RGB components in this build glints off of the sharp edges of the card itself. So yes, perhaps it's not the best GPU for a tight, confined ITX chassis, but if you can supply it with enough airflow throughout a case, the design performs exceptionally well.

01
The radiator bracket here can be a bit finicky to get to sit right once an AIO is installed on top of it. It took a few attempts, and we had to remove the cable bar.

02
Here you can see a bit better why we decided to run the PCIe power cable from the right as opposed to just straight up.

03
MSI's X570 Unify motherboard comes with its I/O shield built in. All you need to do is line the motherboard up with the standoffs and secure it in place.

04
This top 120mm fan was by far the most troublesome part of the build. It's incredibly tight up there with the cables.

Purple passion

And there you have it. We went into this with the aim of building something that could look the part as well as be an impressive performer – and without embarking on a massive liquid-cooled project. This is something that anyone could put together if they have the budget. With the Kraken Z63 at its core, this build shines. The purple-to-white gradient works really well.

The build process was fairly seamless. The H510 Elite is a fantastic case and looks impeccable. It has some caveats that we're not super happy with, the big one being the fan mounts for the top-mounted exhaust, but other than that there's not a lot to complain about. This product area in Nzxt's domain has always been a fantastic mid-range option for those looking for a stylish case that's at home in gaming as much as it is in a clean and professional environment, and Nzxt has really delivered.

But did we achieve what we set out to do? The short answer is: yes, absolutely. That Nvidia GeForce RTX 2070 Super, combined with 32GB of high-spec memory and AMD Ryzen 5 3600X, dominates at 1440p and below, and it's not half bad at 4K either. We saw frame rates of 51fps in *Assassin's Creed Odyssey*, 83fps in *Middle Earth: Shadow of War*, and 71fps in *Total War: Warhammer II*. Outside of *Odyssey*, every one of those titles is above the 60fps mark. Take it to 4K, and you'll net 38fps in *Odyssey*, 54fps in *Shadow of War*, and 39fps in *Warhammer*, all of which are respectable there too.

As for system benchmarks, in CineBench R15 it scored a decent 1,630 points in multi, and 203 in the single-core test. The fact that the RTX 2070 Super is outperforming a standard 2080, in combination with a third-gen Ryzen, shows the difference that CPU architecture has made. It's also a whole lot cheaper than our liquid-cooled attempt too.

We've also had no temperature problems at the time of writing. There's even room right now to give it a bit of an overclock.

So is there anything we'd change? Outside of those fans we mentioned, the other problem areas for us are the motherboard and power supply. That motherboard just doesn't look the part, and it's hardly cheap either. Asrock's X570 Extreme4, or the Asus ROG Strix X570-F Gaming, would suit better and drop the price, without losing M.2 SSD capacity. We could then take the extra cash and spend it on a power supply with pre-sleeved cables or something a bit fancier.

That said, ultimately we're still very happy with how this build turned out, and with that Kraken slowly pulsating away at its heart. It's certainly a good-looking rig.

APC LABS BENCHMARKS

Indicates best result

	Cinebench R15 Multi	CrystalDisk QD32 Sequential	CrystalDisk QD32 Sequential	Middle Earth: Shadow of War	Total War: Warhammer II	Assassin's Creed Odyssey	3DMark: Fire Strike
	Index	Read MB/s	Write MB/s	fps	fps	fps	Index
Purple Haze	1,630	4,918	2,746	83	71	51	1,320
Zero-point	1,320	3,438	2,955	75	65	45	1,701

Our zero-point consists of an AMD Ryzen 5 2600X, 16GB of Corsair Dominator Platinum RGB @ 3200 MHz, an Asus GeForce RTX 2080 OC Edition, and a 1TB WD Black M.2 PCIe SSD. All tests were performed at 1440p at the highest graphical profile.

HOW-TO

TOP TIPS TO TACKLE TECH TROUBLES

QUICK TIPS

APC experts solve computing problems

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

Game folder permission problems

I have a new Asus TUF gaming laptop. I copied a game folder from my desktop PC to a thumb drive, then to my laptop to keep the saved files in sync when I traveled. When I got back, I tried to copy the files back to the thumb drive but got the error, "Your organisation does not allow you to place this file here." I discovered it's the folders rather than the files that won't copy; I was able to create the folder and subfolders on the thumb drive then copy the files in the folder and subfolders, a slow chore. I've searched the Internet for solutions, but, no solution. Where are these permissions in Windows? How do we turn them off?
THOMAS

APC responds: This sounds like the game folder you copied was housed in a protected folder that is owned by a system user (such as TrustedInstaller) rather than your own user account. This error message occurs most frequently in conjunction with the hidden WindowsApps folder where programs installed through the Microsoft Store reside, but if you installed the game through other means, it's possible that the installer set permissions in such a way as to prohibit (or at least discourage) folk from copying the game.

Sadly, without knowing what the game is, what was in the folder you were copying, and where you installed it from, the Doc can't offer specific advice in this instance, but he's certainly not going to recommend messing about with permissions without knowing more, as you could quite easily trash your enitre Windows installation.

What the Doc would suggest is that you install the game separately through the usual channels on both laptop and desktop, then look for an alternative means of backing up and transferring game-save data between them – for example, GameSave Manager (**www.gamesave-manager.com**) supports over 6,800 games. Just download it, extract it to your USB drive, and then run it directly from there to transfer your saved games between machines.

Unwanted temp files piling up

Hello – for months now there has been junk files in the %temp% folder with the name mat-debug-xxxxx.log – where the numeric part seems to be the PID of the process that created it. These files are zero bytes, but in some cases I found over a dozen of them, and a new one seems to be created every 10-15 minutes or so.

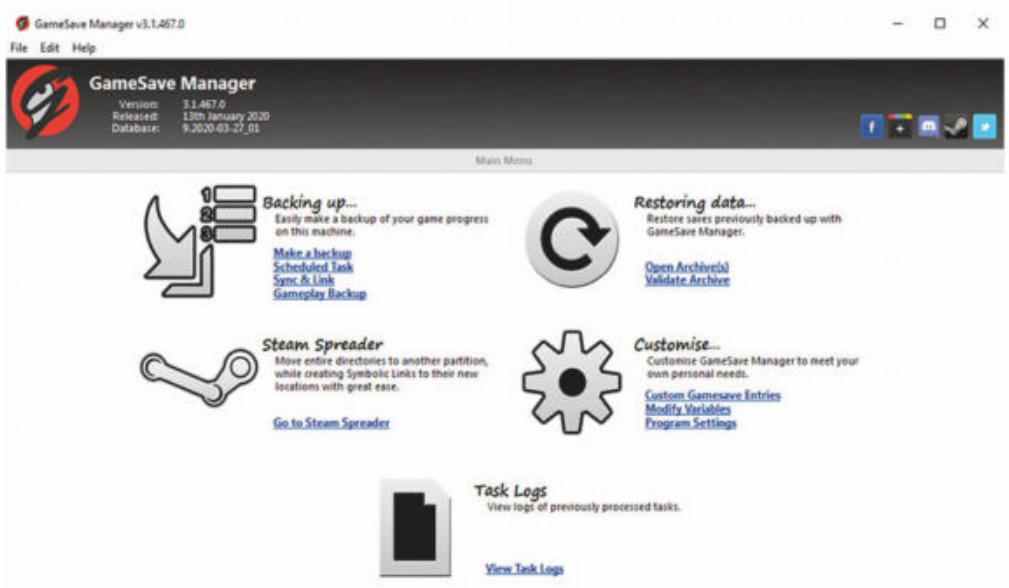
They seem to reproduce like rabbits. There have been numerous posts in the Microsoft forums, with all sorts of ways to stop this, but for me none worked – is there a way to stop these files from being created?
FRANK ESPOSITO

APC responds: These files have only started appearing relatively recently – possibly since the last major Windows update (1909). There are several theories for where they come from – some claim they're linked with graphics drivers, others point towards Office telemetry. From what we can gather, there is no definitive information out there as to what these files are, but they're a cause for irritation rather than genuine concern.

Given the Temp folder is always full of files you'd normally ignore in day-to-day use, the key here is to manage things so that it doesn't fill up to clog up your entire drive. Thankfully, the folder – among other temporary files – can be kept in check using Storage Sense: head over to "Settings > System > Storage," flick the switch to on and then click "Configure Storage Sense or run it now." Choose how often it should run, and make sure the "Delete temporary files that my apps aren't using" box is checked. If need be, you can scroll down and click "Clean now" to perform a quick cleanup, which will delete all files in the Temp folder that are older than a week.

Where's the love for SSHD?

Your magazine has nearly become a solitary blueprint for my hobbyist build ideas, and I found myself wondering the other day why SSHDs aren't more talked about in general. I have used them in a few super-budget builds lately, and they seem to show promise for the cost. Would you consider doing a product comparison with SSD vs SSHD vs HDD? Or, perhaps a head-to-head comparison of the top SSHDs and an SSD control subject? I'm curious to know your thoughts from a cost/benefit perspective. Even a piece on how they work would be interesting. Thanks for the endless info, tips, and tricks!
SHANNON BENIKOSKY



Manually copying game-save folders can cause problems.

APC responds: Solid State Hybrid Drives represent a snapshot in time when the price of SSD storage was still prohibitively high. As the name implies, they combine a regular spinning-platter drive with a small amount of SSD storage (typically 8GB, although some models support 32GB). The drive then identifies the most frequently accessed files on the drive, placing them on the SSD portion to speed up access.

While SSD drives were relatively expensive, SSHDs offered a smart compromise between capacity and performance. They're obviously not as quick as full-blown SSDs because most files remain on the slower portion of the drive, but they're a vast improvement over regular hard drives when it comes to boot and application load times.

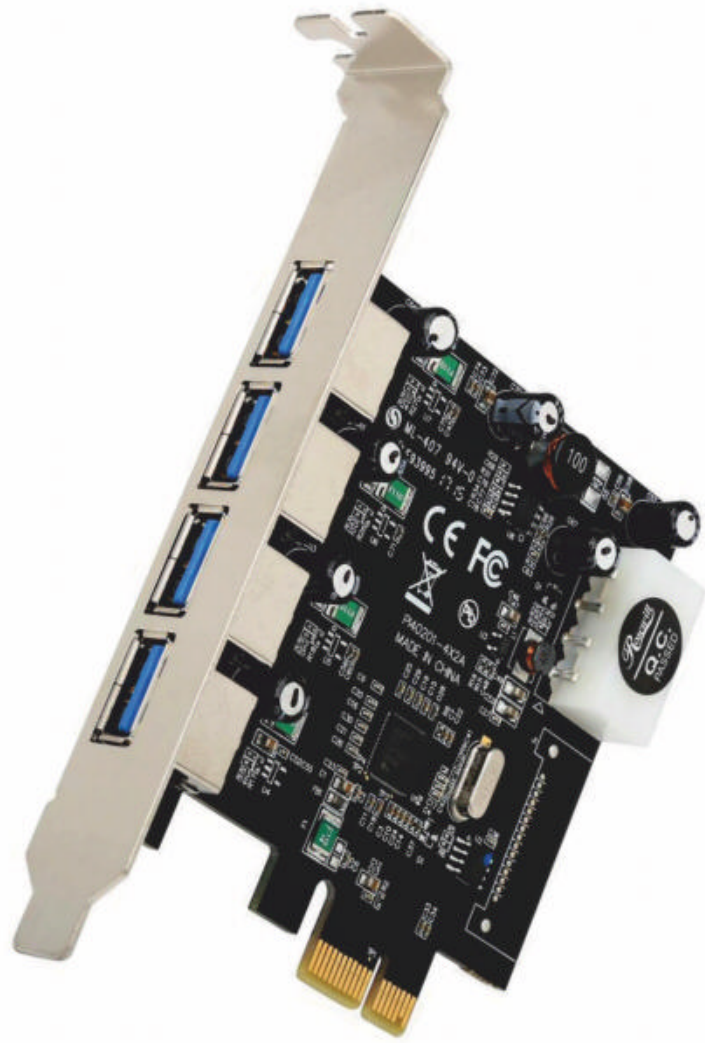
When it comes to cost, a direct comparison between SSHD and SSD appears to confirm that SSHDs still hold a significant advantage: you'll pay $160-$180 for a 2TB SSHD – less than half the price of a 2TB SSD. That seems like a no-brainer for those on tight budgets, but consider this: you can buy a 120GB SSD for under $50, and a 2TB regular hard drive for around $100. So, for less than the price of a single 2TB hybrid, you can have a fast 120GB boot drive and 2TB drive for storing files, while keeping data separate from Windows and apps.

SSHDs may no longer hold the same appeal from a price perspective, but they do still possess one major advantage: they're perfect for when you only have space for a single drive, and need both performance and capacity – typically in laptops.

Sadly, *APC* sees no future for SSHDs, as SSD prices continue to tumble – if the onboard SSD storage was 64GB there might be a stronger case for them, but 8GB looks to be the norm, so they are less compelling, even for those on a budget.

USB 3.0 port problem

My old Win7 x64 desktop, GA-H61MA-D3V (rev. 2.0) motherboard + Intel Core i5 3550 has two rear USB 3.0 ports, and they have not worked for a few years. Peripherals plugged into them light up, but there is no Windows recognition. Device Manager has no errors, but should I be suspicious that there's no reference to USB 3.0 under "USB controllers"? I've installed the latest BIOS and drivers from Gigabyte, including the Etron USB 3.0 drivers. Can USB ports go bad?
CURTIS RAFF



Replacing busted USB ports isn't expensive.

APC responds: Your mobo's Etron EJ168 USB 3.0 host controller has been plagued with problems over its lifetime, but the lack of any reference to an "Etron USB 3.0 eXtensible Host controller" in Device Manager is very suspicious. Try reinstalling the Etron USB 3.0 drivers again – the latest version via Gigabyte is 1.0.0.118 from November 2013, which is the latest version available (see **https://bit.ly/MPC178usb** for an alternative download).

If this driver fails to install, boot into your BIOS setup utility, navigate to peripherals and verify "USB 3.0 Support (Etron EJ168 USB Controller)" is enabled – if it's not, switching this on should bring things back. We suspect it's already enabled, so your next step is to see if you can get the ports recognized in Linux. Create a live Linux CD using a distro running Kernel 5.2 or later (Ubuntu 20.04 LTS or 18.04.4 LTS both meet this requirement), and run it in "Try" mode. Connect a USB storage device to one of the USB 3.0 ports, and it should show up in the "Files" tool.

If nothing shows up in Linux, then it's safe to write off the ports. Thankfully, your motherboard has three PCI-Ex1 slots, so you could purchase a USB 3.0 PCI-E plugin card like the Astrotek 4-port USB 3.0 card ($25), to restore USB 3.0 support to your PC.

Can't switch HP function key lock

I purchased an HP Pavilion All-in-One 24-xa0119, which is swell but for one very annoying issue: it comes with a sleek keyboard that has the multimedia functions on the function keys, forcing me to hold Fn to use them as actual function keys. Every other keyboard I've used has done the opposite – I regularly use Photoshop, and I have actions that I run using the Function keys for repetitive tasks. I don't wish to use fn+F2 to run my crop action, nor do I want to buy another keyboard.

Older HPs let you change the setting in the BIOS, but this is not present here. As an HP employee on their forums said, "I must let you know that this isn't an issue, it's by design, Function key settings are only available for laptops, the default function for all-in-one devices cannot be changed." Without getting into the stupidity of this decision, is there any way to override this design choice? A script of some sort that auto-runs with Windows, or some registry tweak? None of the combos I have read online (fn-Esc, fn-Caps lock, fn-Shift) turn fn lock on. There is no fn lock key or indicator on the keyboard.
BRIAN DI CESARE

APC responds: The HP forums are littered with irate users such as yourself, Brian, and for good reason. What possessed HP to remove any option – within Windows or in the BIOS – to allow you to switch the order back to what most people consider logical is beyond us. The problem isn't limited to all-in-one users either; HP sells the offending keyboard (a Pavilion 600 wireless model) standalone too.

You could try a few more combos such as fn-Ctrl-Alt, or fn-Ctrl-Shift, or even Fn-Win – but we suspect you're stuck with the keyboard's foibles. If that's a deal-breaker, you'll find plenty of sleek, wireless (and unbranded) keyboards on Ebay that behave properly and won't look out of place next to your all-in-one PC. They're relatively cheap too. That said, HP should perhaps offer some kind of exchange program for those who find the keyboard's foibles too much. ■

WINDOWS

Benchmark your CPU like *APC*

Christian Guyton shares how we benchtest, so you can, too.

Benchmarking can be an arduous process, full of frustration and confusion. Why won't this test run? Why is this result so low? The sheer amount of different benchmarks is no help; hunt for figures for a specific component and you might end up with dozens of meaningless results.

But never fear; we're here to show you how we do things, starting with how exactly we test CPUs. If you're curious about the performance of your system, or you're assembling a fresh build and want to show off your specs, then benchmarking is the way to do it. In this tutorial, we're going to explain each of the tests we use to evaluate the performance of processors.

It's worth noting that this guide is specific to Windows systems; we typically install Windows 10 on every system we build or test. We're also not going to get stuck into gaming benchmarks here, since they generally require ownership of the game and are usually simple to run, with a standard average frame-rate result.

The simple stuff

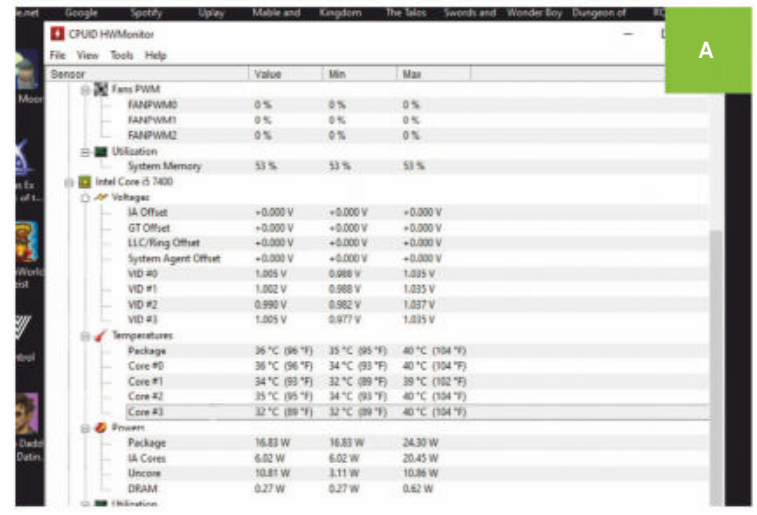
Plenty of the CPU benchmarking software we run can be downloaded for free as a trial version, which is ideal for testing out your own system at home. You may, however, want to activate an ad-blocker before downloading these; some freeware sites are rife with fake download buttons and intrusive ads. First up is AIDA64, a system-information tool, the Extreme edition of which can be downloaded with a 30-day free trial. We primarily use AIDA64 Extreme for benchmarking the system memory and CPU together, as it enables you to view real-time latency for the overall RAM and individual CPU cache speeds.

AIDA64 also provides a staggering amount of general system information, as well as benchmarks for memory, drives and GPUs. The latter includes integrated graphics tests, an ideal way to check the performance of the IGPU. The program even includes direct links to Intel's ARK website, which contains just about every bit of information about Intel processors. It's worth noting, though, that the trial version of the software does limit some features and test results.

On your mark

Another program with a free trial (although we'd recommend buying the full version if you're building or tweaking a system and want to run multiple tests) is PCMark – versions 8 and 10 are commonly used. Both are relatively straightforward system-benchmarking programs, putting your machine through its paces and spitting out a number at the end. PCMark 8's trial version is slightly more comprehensive, including Creative and Work preset benchmarks, as well as the standard test.

The result you get from PCMark's benchmarks isn't a 'real' figure as such. It doesn't provide any specific data on how your PC is performing, but instead gives an indexed number that's meant to be compared online. **https://benchmarks.ul.com** keeps track of assorted scores for CPUs, and the paid version of the program can record and compare multiple scores. Once you've run the benchmark on your system, you can easily check if it's performing on par with similar PCs. There's even leaderboards, where experienced system-tweakers can show off how far they've been able to push their processors. You can use HWMonitor **[Image A]** in the background (see boxout Keeping Score) to check how hot your processor gets during benchmarks.



A

YOU'LL NEED

PC or laptop (preferably with a CPU). A screen, mouse, keyboard and Internet connection. An ad-blocker, or superhuman tolerance for ersatz download buttons.

Blender render

Next up is the Blender benchmark. For the uninitiated, Blender is an excellent piece of open-source 3D modeling software, available for free at **www.blender.org**. However, it can also be used as a 3D-rendering benchmark for your CPU or GPU, using one of the ready-made render tests available under "demo files" on the Blender website. We use the "Car Demo"", a detailed 3D model of an orange BMW, with version 2.82 of Blender. The process is relatively simple; install Blender and download the demo file, then open it in Blender and begin the render process using the toolbar at the top of the screen. The total time taken to render the image is the point of comparison here; the faster the better. We convert this into a pixels per second, or pps, figure by dividing it by the total pixel count (i.e. the image resolution). The demo file download includes two files – one for CPU testing and another for GPUs; so check

Full throttle

If you're overclocking your CPU, benchmarking and stress-testing software is vital. Prime95 offers a free way to stress-test your CPU; for our CPU reviews, we use its "torture test" option to max out the processor as an overclock-stability check. Leaving Prime95 running for a few minutes will let you reach the effective maximum running temperature. If that temperature exceeds safe levels, however, your processor will throttle and eventually trigger a system shutdown to avoid damage to the chip. We recommend using Prime95 in conjunction with HWMonitor to keep an eye on core temperatures in real time. The chip's max operating temperature can be found online from AMD or Intel; this way, you can see if your CPU is approaching dangerous heat levels, and shut down Prime95 before your system crashes. If your chip overheats; lower the voltage or target frequency and try, try again. Eventually Prime95 should run indefinitely without the processor rising above safe temperatures.

you're using the right one!

Another free rendering benchmark we use is Cinebench. As you might have guessed from the name, this is a dedicated piece of CPU-benchmarking software that uses your processor to perform a high-intensity render test, and assign you a score that can then be compared against other processors. Cinebench will even save benchmark scores in-app, making it an ideal before-and-after test if you're changing your processor. We use Cinebench R15, although the R20 version is also available for free. This benchmark is as simple as it comes, giving you a nice "Run" button in the upper left corner of the screen. This will run the all-cores version of the test; under File > Advanced Benchmark, you can find single-core and OpenGL tests to run as well.

It's complicated

We've kept the more complex stuff for last. POV-Ray is a ray-tracing program that generates an image, allowing you to calculate another pps statistic for your processor. POV-Ray can be downloaded for free at **www.povray.org**, and also features a page detailing how to benchmark with the program. The standard download includes a test file, imaginatively named "benchmark.pov", which provides a common environment for CPU tests so that they can be compared online. To run it in POV-Ray 3.7 for Windows, find the benchmark command in the Render Menu in-app, or use the /BENCHMARK command-line option.

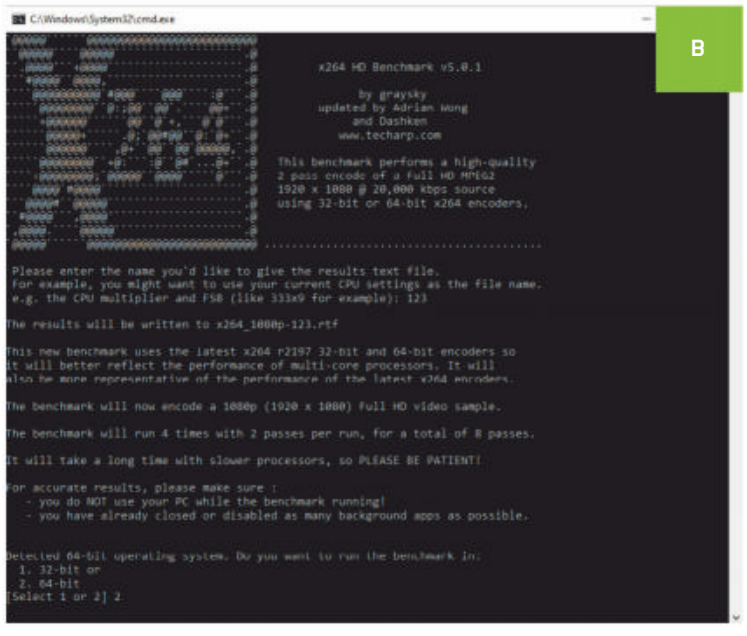
Perhaps the most troublesome piece of software we use to test CPUs is the x264 video-encoding benchmark **[Image B]**, created by Malaysian tech news website Tech ARP. Tech ARP also offers a handful of other CPU tests. It can be a struggle to set up, as it requires two specific pieces of matched software; the benchmark program itself, and a secondary install called AviSynth; a scripting language designed for video-editing tasks.

Once you've downloaded the x264 benchmark, you should have a "run" VBScript file. Run that as administrator, and it will open a text box redirecting you to an online download source for AviSynth on **https://sourceforge.net**. Don't just hit download; x264 will tell you which version of AviSynth you need, in our case 2.5.8. You can find the different versions under "files" on the webpage. Once the correct version of AviSynth is installed, you'll be able to run the x264 benchmark by reloading the text box. All you need to do is name the test (we would recommend naming it after your CPU), and select the 64-bit version of the benchmark.

This benchmark can take a very long time to run – especially on older systems – so be patient with it. Ultimately, it'll give you an average frames-per-second figure that you can compare with other users. And that's it! You have now learned everything you need to know to benchmark your CPU just like us.

If it takes your fancy, bash your CPU with a final stress test using Prime95, a free "torture testing" program to check that your CPU isn't overheating or throttling. Now go forth, and find out exactly how good your system is. ■

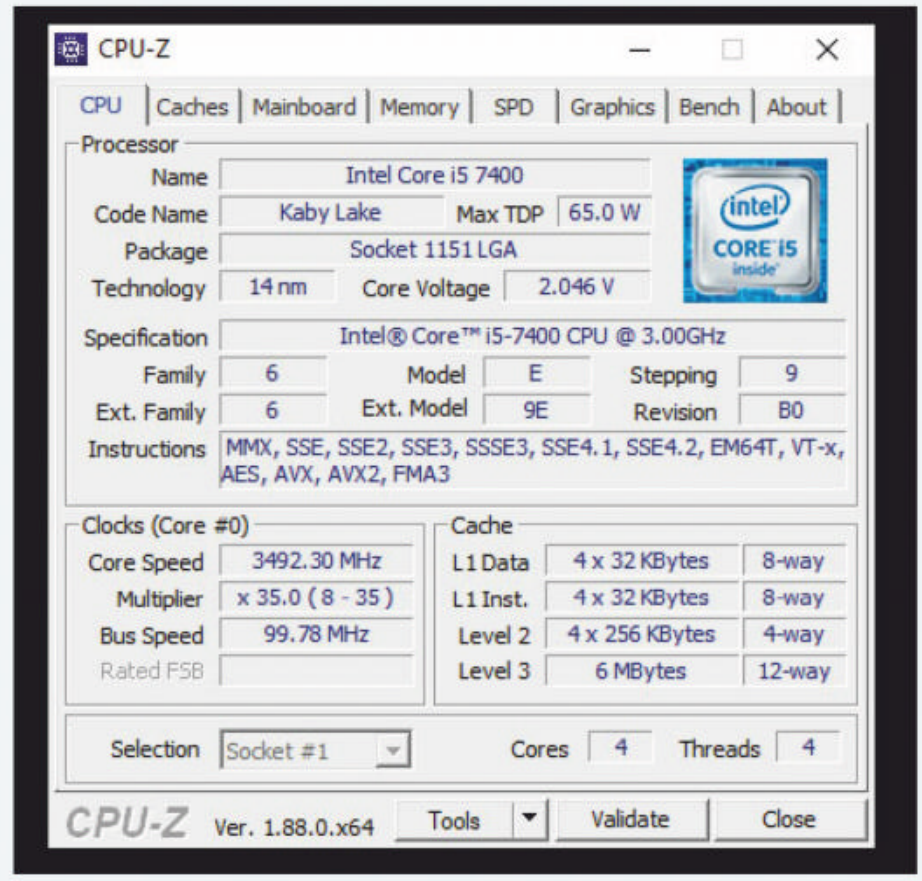
B

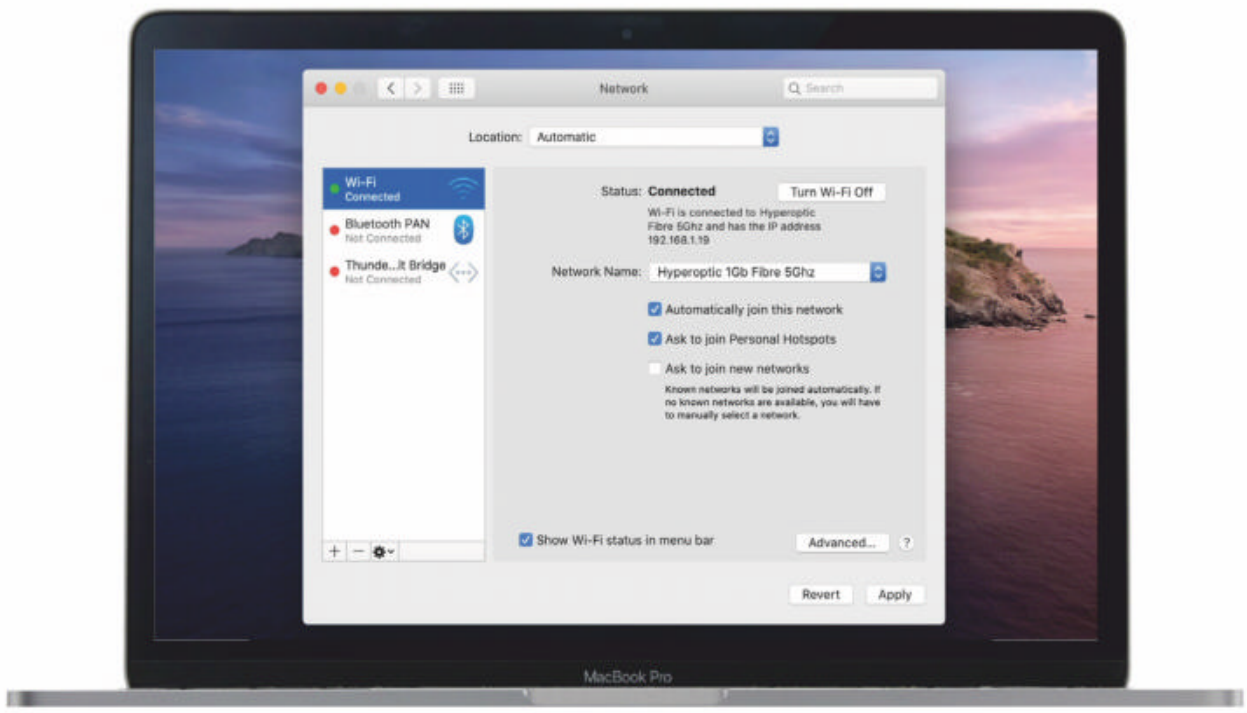


Keeping score

We run a wide variety of tests on CPUs, using more software than we mention in our benchmarking tables. There are two pieces of non-benchmarking software we'd advise downloading; CPU-Z and HWMonitor. Both programs are freeware available from CPUID online, with a simple, ad-free download and setup. CPU-Z provides detailed system information, useful for checking what components are inside a system, while HWMonitor gives you live numbers for a wide variety of stats, from individual core clocks to component temperatures.

The latter program is vital for CPU testing, since min-max tracking enables you to check the peak temperatures your processor hits while you're running other benchmarks – particularly useful for keeping an eye on your CPU when stress-testing with a manual overclock. It can also be invaluable for identifying problem spots; for example, if one CPU core is being over or under-utilised, or if your motherboard temperatures are causing your CPU to throttle. HWMonitor's own CPU usage is very low, so you can leave it running while you perform other tests.





MAC

Manage your networks

Connect to the right network every time. Cliff Joseph shows the way.

Networking is one of those things that can really make your head hurt. Fortunately, high-speed Wi-Fi networks are pretty common these days, and the macOS makes it easy to automatically connect to Wi-Fi, whether you're at home, in your office, or in a public place such as a coffee shop that offers free Wi-Fi to use.

Sometimes, though, you might need to take more direct control of the network settings on your Mac – particularly if you use a Mac at work, or have a MacBook laptop that you use in a number of different locations from day to day. Some locations may have multiple Wi-Fi networks available, while many businesses prefer to use wired networks with ethernet cabling in their offices.

There may be times when you want your Mac to use just one specific Wi-Fi network, or even tell your Mac to ignore Wi-Fi altogether and to only use an ethernet connection for an office network. Fortunately, the macOS allows you to use different network settings in different locations, so brush up your network know-how with our quick guide.

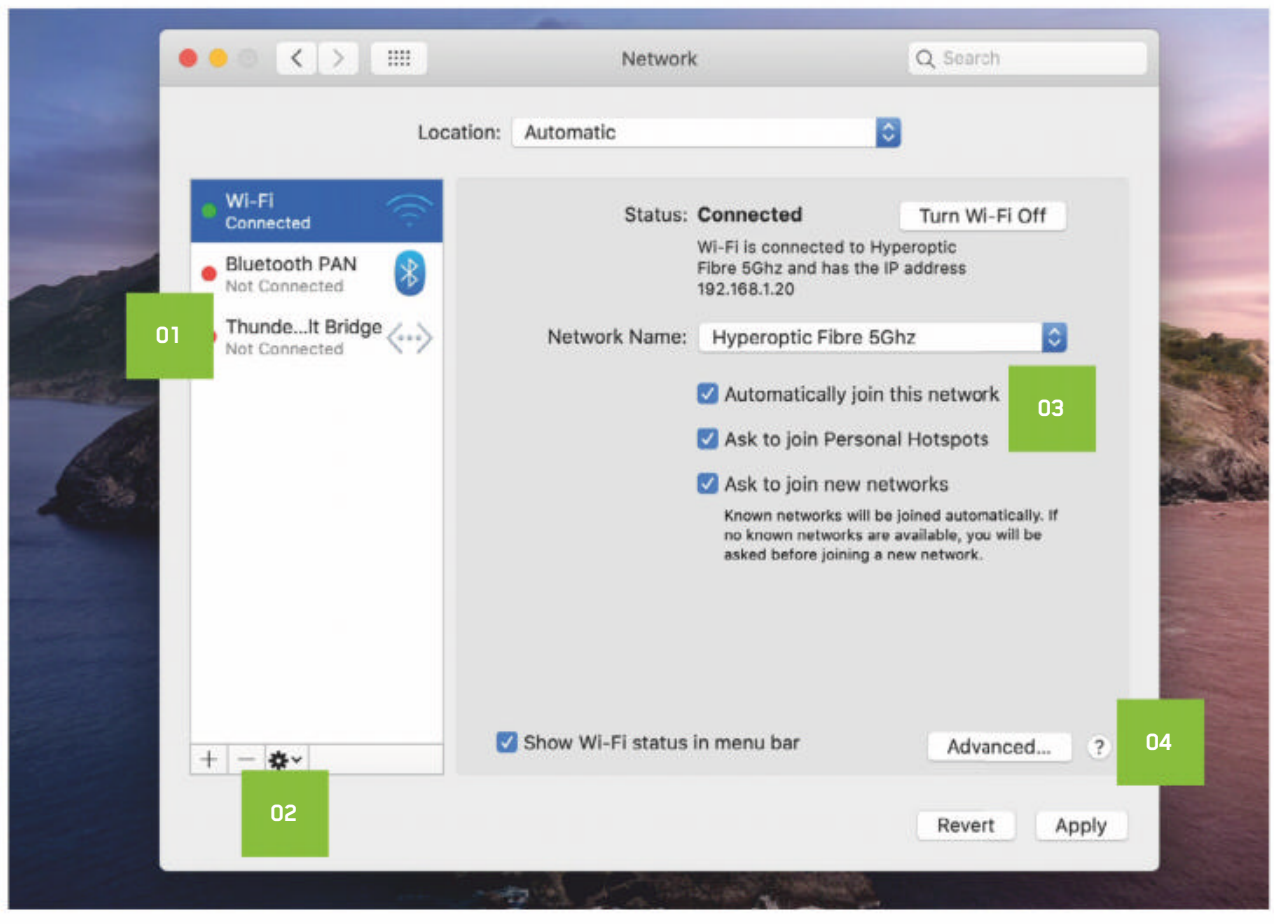
"There may be times when you want your Mac to use just one specific Wi-Fi network, or even tell your Mac to ignore Wi-Fi altogether and to only use an Ethernet connection for an office network."

IT WILL TAKE
15 minutes

YOU WILL LEARN
How to choose the right network connections for your Mac

YOU'LL NEED
Any Mac, with an internet connection or office network

EXPLAINED: Network settings in macOS.



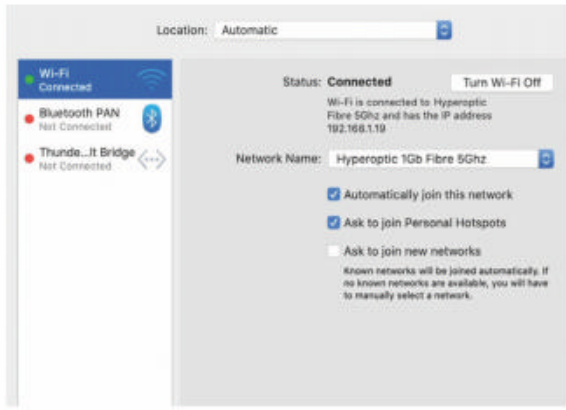
01
RIGHT CONNECTIONS
This list shows all the wired and wireless network connections that are built into your Mac.

02
WI-FI OR WIRED?
The settings menu allows you to prioritise different types of network connection.

03
ASKING PERMISSION
Your Mac can automatically join a Wi-Fi network, or ask for your permission first.

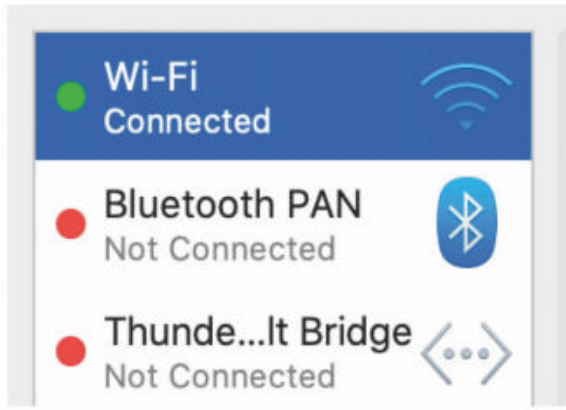
04
DIGGING DEEPER
The '?' icon provides help for beginners, while advanced users can explore technical details.

HOW TO: Manage networks your Mac connects to.



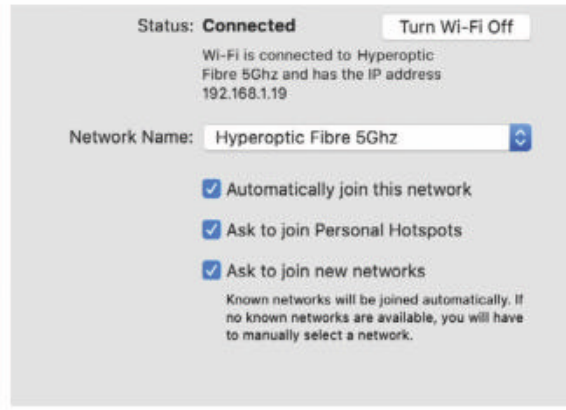
01 NETWORK SETTINGS

Open System Preferences and click Network. The networking options shown here will depend on what type of Mac you have – MacBook laptops tend to rely on Wi-Fi, but desktop Macs will also have Ethernet ports for wired networks.



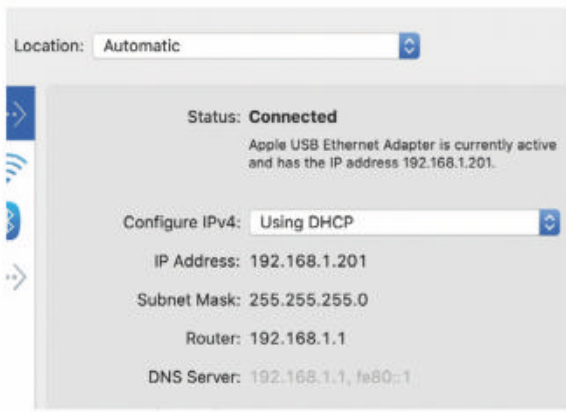
02 JUST IN CASE

You'll probably never need to do this, but you can use Bluetooth to connect to mobile broadband via a smartphone. It's also possible to set up a quick mini-network between Macs using their Thunderbolt ports.



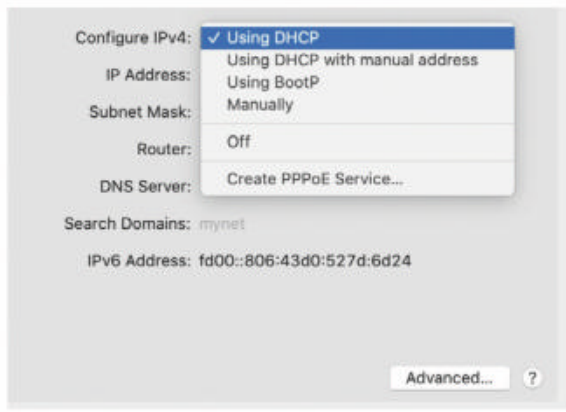
03 WHICH WI-FI?

Many offices and blocks of flats may contain several different Wi-Fi networks, so you can use Network settings to specify which network to use. You can also tell your Mac to ask permission before joining other types of network.



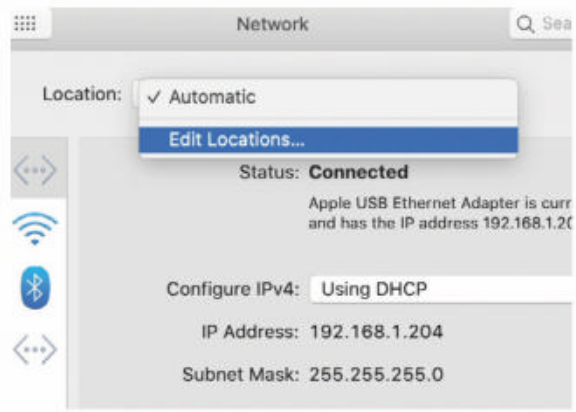
04 PLUG AND PLAY

Desktop Macs will show an additional set of controls for ethernet networks – and you can also add ethernet to a laptop by using Apple's USB ethernet adapter. Just plug the adapter in and your Mac will detect it automatically.



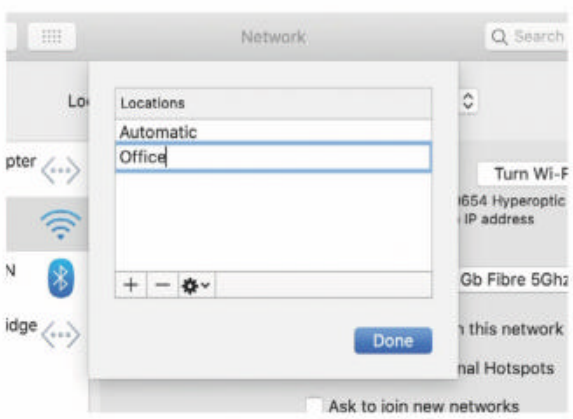
05 OFFICE OPTIONS

You can generally rely on the default DHCP option for connecting to an Ethernet network. However, some office networks may need you to enter additional settings using this menu, or the Advanced button below.



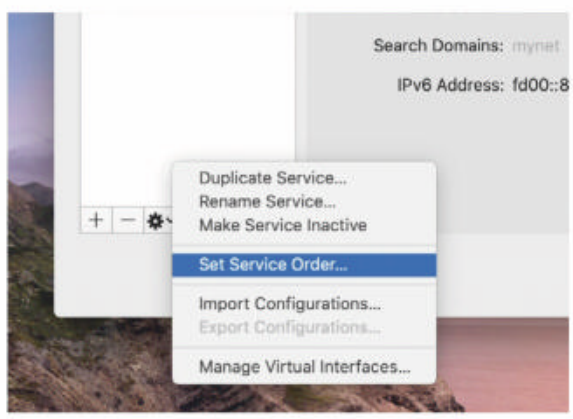
06 LOCATION, LOCATION

If you mainly use Wi-Fi at home, leave that as the default Automatic setting. However, if you often switch to Ethernet when you're at work in the office, click on the Location menu and select Edit Locations.



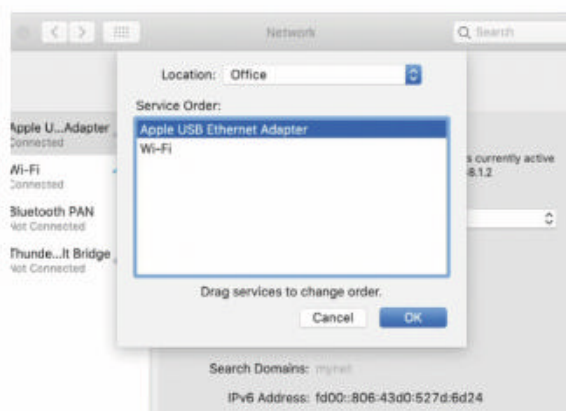
07 HOME AND AWAY

The standard Automatic setting just grabs the first network connection that it finds. That's fine for accessing your home Wi-Fi, but you can also create new network settings to be used in a specific location, such as your office.



08 CHOOSE A NETWORK

Click the gear icon to view additional settings. The Set Service Order option tells your Mac to connect to networks in a specific order, or you can opt for Make Service Inactive to completely ignore a particular type of network.



09 NETWORK PRIORITY

Here, the Service Order for 'Office' tells the MacBook to connect to ethernet if possible, but to fall back on Wi-Fi if needed. You can create additional settings for coffee shops, hotels and other locations.

"Even before you try to drift off, Night Shift can help reduce the strain on your eyes by reducing the blue light from the screen, helping to prepare your body for sleep."

iOS

Get a good night's sleep

Srivats Lakshman walks through the steps to ensure you get adequate sleep with tools built straight into your iPhone.

When it comes to your health and fitness, sleep is as important as exercise. The average adult needs between seven and nine hours of sleep every night. A lack of sleep can lead to poor decision making, high blood pressure, low mood, and weight gain, among other issues.

Enough of the scaremongering: your iPhone can help you get a good night's rest! Over the years, Apple has built several tools into iOS, such as Do Not Disturb that can be used to help you sleep. You may also be tempted to use a sleep-tracking app, but did you know Apple has that feature built straight into the Clock app?

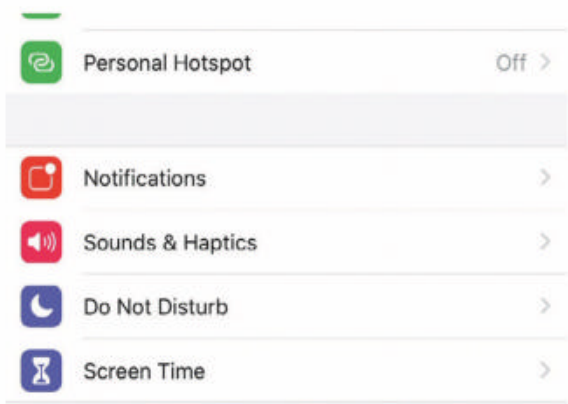
Even before you try to drift off, Night Shift can help reduce the strain on your eyes by reducing the blue light from the screen, helping to prepare your body for sleep. While the iPhone cannot help track more complex issues like sleep apnoea, it is still a very powerful tool that can help you track your time in bed.

IT WILL TAKE
15 minutes

YOU WILL LEARN
How to use your phone to help you sleep

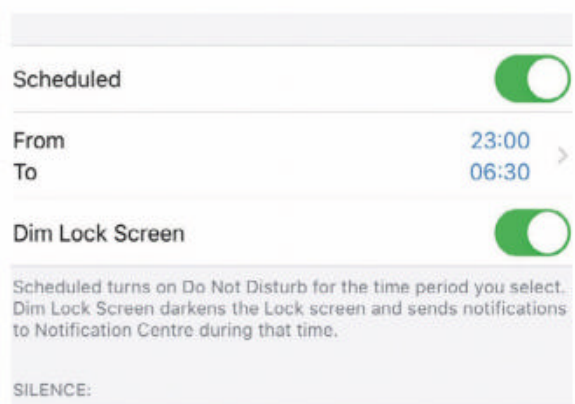
YOU'LL NEED
An iPhone with iOS 13

HOW TO: Schedule Do Not Disturb



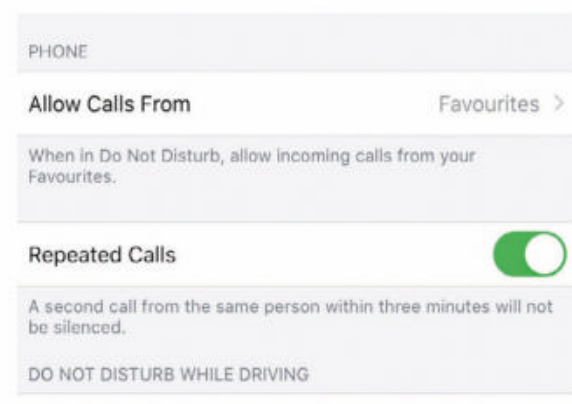
01 OPEN SETTINGS

Do Not Disturb can be turned on from the Control Centre at any time, or activated via Siri. However, if you want to schedule it to turn on and off automatically, go to Settings > Do Not Disturb (the crescent moon icon).



02 CREATE A SCHEDULE

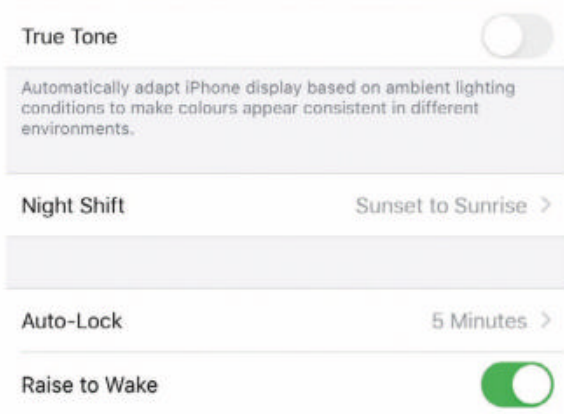
After enabling Scheduled, you will see an option below with From and To. Tap this to open the timer-like interface and select the times. Unfortunately, you cannot specify which days you want the schedule to apply to.



03 FINE-TUNE SETTINGS

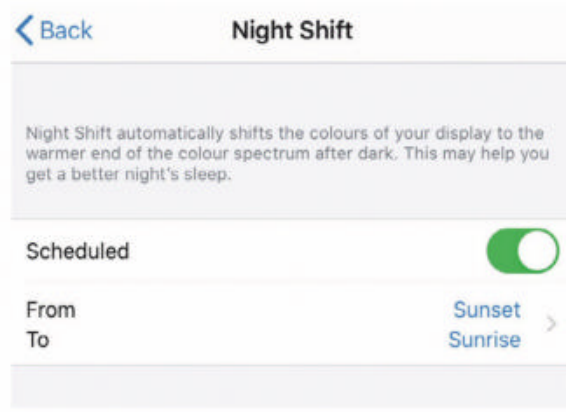
When Do Not Disturb is enabled, you can allow calls from Everyone, No One, Favourites, or specific contact groups. If you turn on Repeated Calls, a person who calls you twice within three minutes will be allowed through in case it's important.

HOW TO: Enable Night Shift



01 GO TO SETTINGS

To schedule Night Shift, you will need to go to Settings > Display & Brightness. The feature can also be enabled from Control Centre, by firmly pressing the Brightness slider. Night Shift will then appear as an option below the slider.



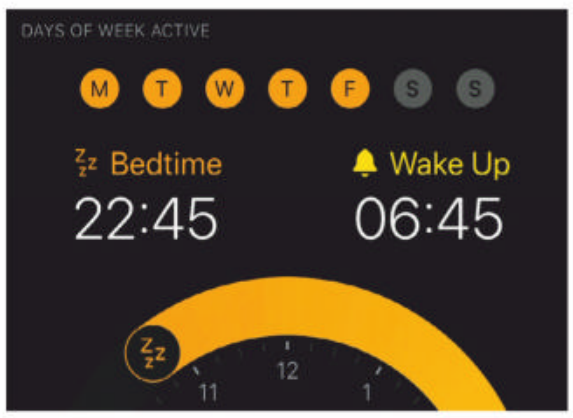
02 SCHEDULE NIGHT SHIFT

Tap Night Shift, then tap the Scheduled option. You can either pick from Sunset to Sunrise (determined by the geolocation of your device) or Custom, allowing you to enable the feature around your sleep schedule.

03 PICK TEMPERATURE

Night Shift reduces the amount of blue light emitted by the screen by shifting the colours of the screen towards warmer temperatures. You can use the slider to adjust the warmth of the screen when the feature is enabled.

HOW TO: Track your sleep

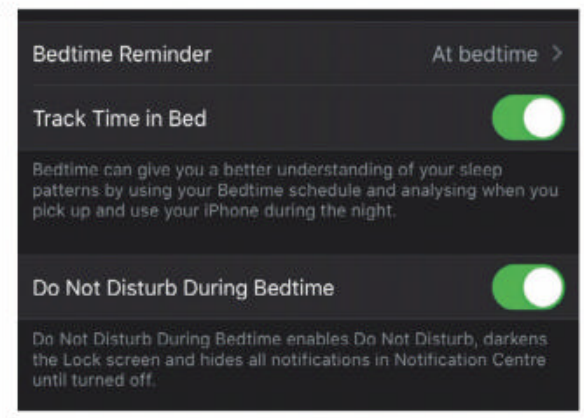


01 SET UP BEDTIME

Open the Clock app. You'll see Alarm, Bedtime and Stopwatch. Tap Schedule and turn on Bedtime Schedule. Tap each day you want the schedule to be active. Use the interface to select what time you want to go to bed and wake up.

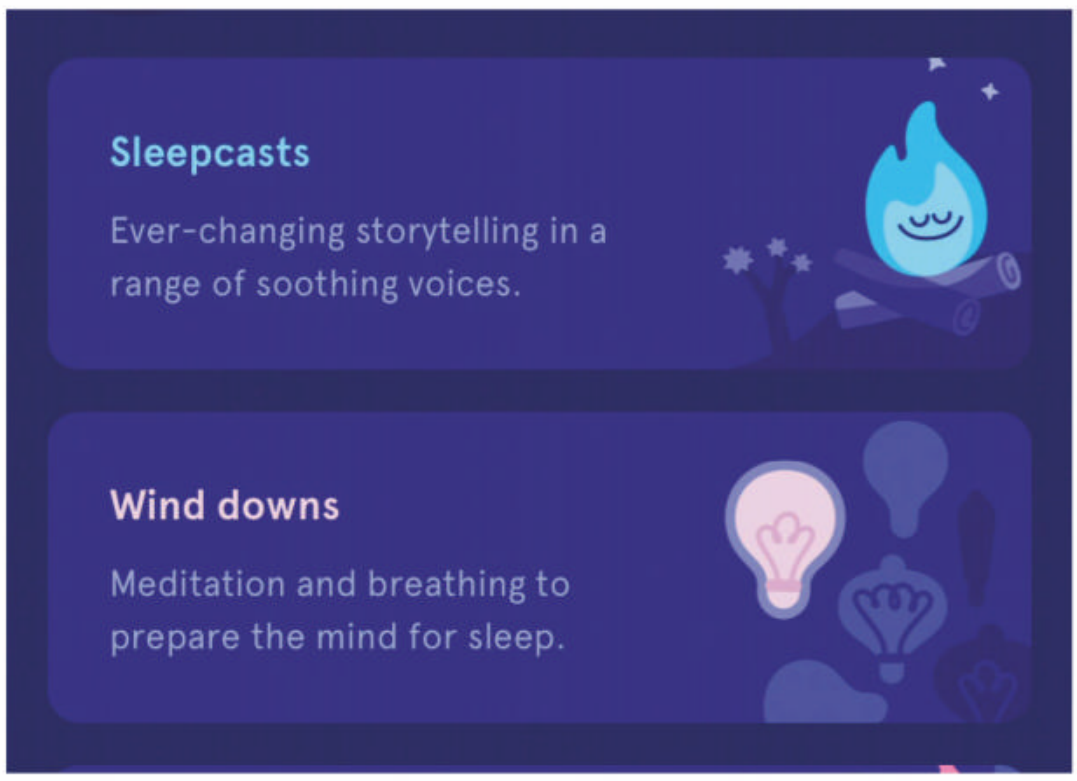
02 SCHEDULE BEDTIME

As you adjust the timings, you'll see the hours you'll spend in bed. If you use your phone during your scheduled Bedtime, the time you use it will not be counted in your total sleep hours. Data from Bedtime can be viewed in Health.



03 REFINE BEDTIME

Tap Options in the top right of the Bedtime screen. Here you can set a reminder for bedtime, and enable Do Not Disturb while Bedtime is active. From here, you can also pick your alarm (called Wake-Up Sound) and set the volume.



More ways to get better sleep

From lights to sounds, falling asleep made easy.

If you have trouble falling asleep, try changing the temperature of your lounge and bedroom lights. Use warmer colours like yellow, orange and red. Cooler colours like blue and green can trick the body into thinking it's daytime, and suppress production of the melatonin hormone. As the sun goes down, melatonin production increases, and your body recognises that it is time to sleep. In addtition, there are plenty of meditation and sleep-aid apps that produce relaxing sounds; listening to natural sounds is a proven way to relax the mind and body.

LINUX

Extending VIM functions with plugins

Being quite versatile himself, it's no wonder Shashank Sharma has such fondness for the highly extendable Vim.

Vim is a fiercely popular and featureful text editor, and you can enhance your Vim experience by enabling some advanced options such as auto-completion, smart search, and even polish your writings by using a thesaurus and dictionary.

While all that can be done with a vanilla Vim installation, albeit with some modifications to the configuration file, with different plugins you can get additional useful features such as creating bullet lists, and can even transform Vim into a password manager, and more.

Before we do that, however, it's imperative to learn how to install plugins. The easiest way is to download the individual files into a dedicated directory, and update the ~/.vimrc file. The downside to this approach is that you have to manually install updates for each of the plugins as they become available. This is still not a problem if all you have is half a dozen plugins, but what if you had more? There are dozens and dozens of plugins that you may wish to use at one time or another, and manually fetching each is unnecessarily painful. You can instead use a plugin manager, which makes installing, updating, and deleting plugins a breeze.

Vundle and Pathogen are also quite popular plugin managers for Vim, and work much the same way as vim-plug.

Using Vim-plug

Our favourite plugin manager is vim-plug, which is quite straightforward to set up and use. To begin, open a terminal and run the `curl -o ~/.vim/autoload/plug.vim https://raw.githubusercontent.com/junegunn/vim-plug/master/plug.vim` command. If you already have a ~/.vim/autoload directory, you can alternatively navigate into this directory and download the plug.vim file with `wget https://raw.githubusercontent.com/junegunn/vim-plug/master/plug.vim`

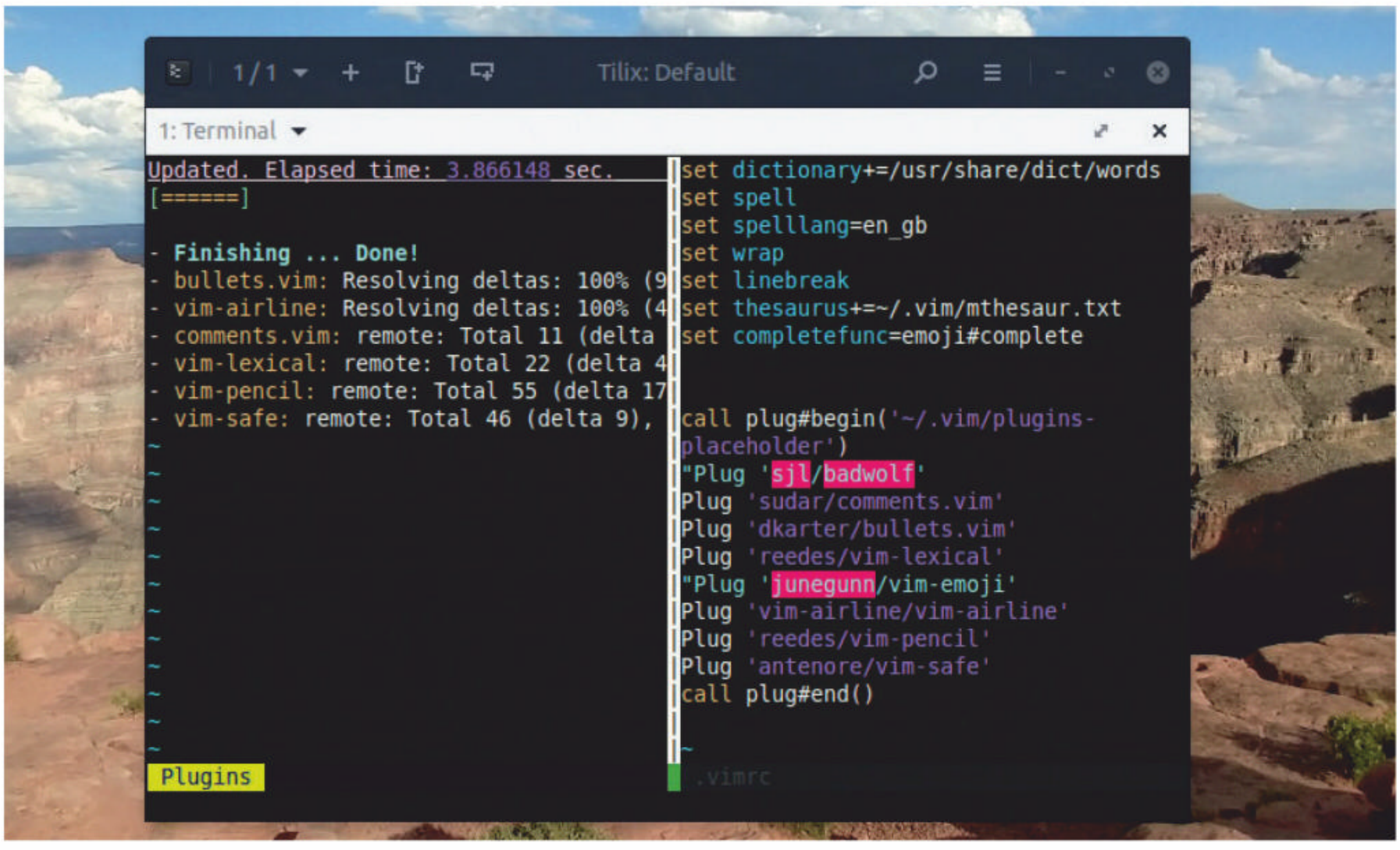
The next step is to inform Vim to use vim-plug plugin manager. You need to edit the ~/.vimrc file and add the following lines:

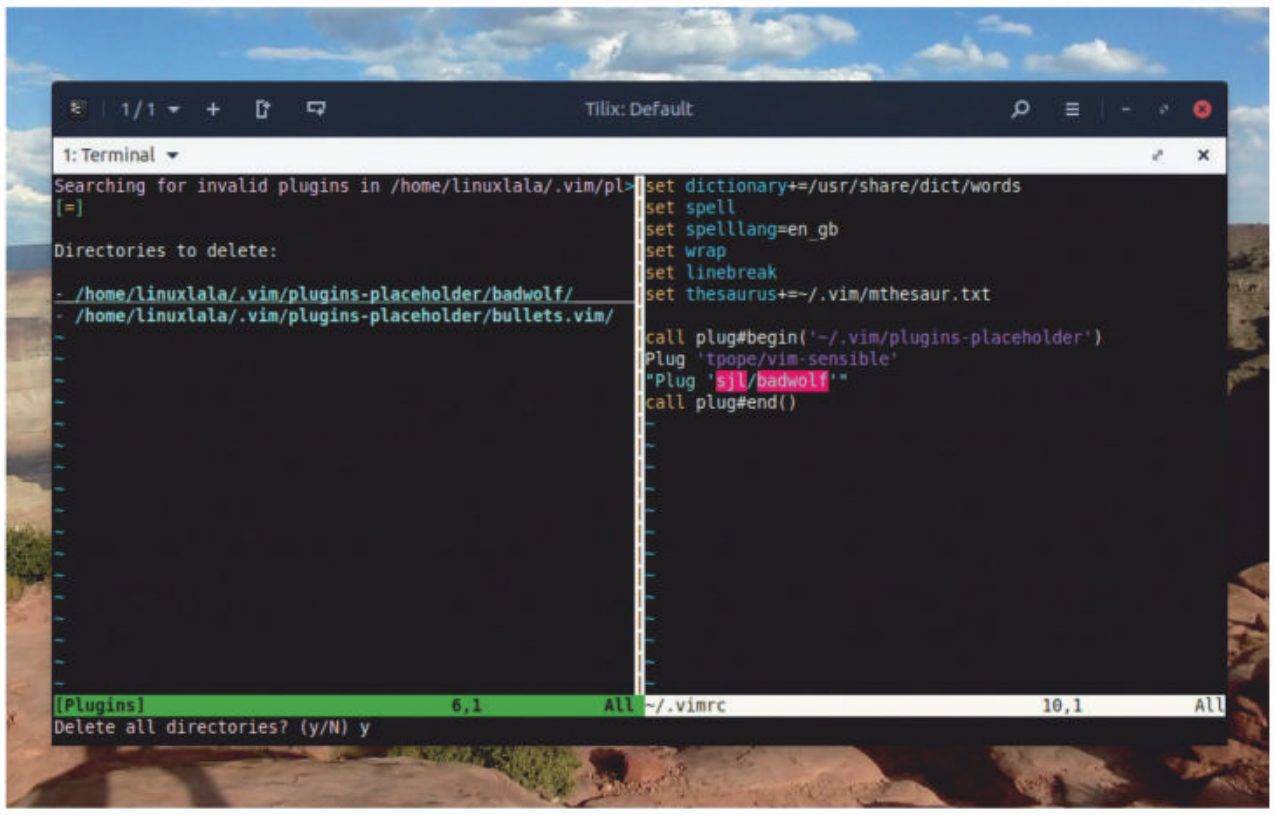
```
call plug#begin('~/.vim/plugins-placeholder')
call plug#end()
```

Leave the rest of the ~/.vimrc file unchanged for now. In the first line, you must provide the complete path to a directory where Vim-plug will store all the downloaded plugins. The project suggests using any name for this directory, except standard Vim directory names like 'plugins'. The single quote is also part of the line, so make sure to type it along with the path name.

Normally we would advise you to use any text editor to edit configuration files, but in this instance it makes sense to make the changes using Vim. After making the changes to ~/.vimrc file, save the file by pressing Esc and typing `:w` . Now, while Vim is still running, press Esc again, and type `:source %` . This reloads the ~/.vimrc file so that vim knows to use the vim-plug plugin manager now. The `%` symbol is used to tell Vim to use the current file. You can alternatively type the complete path with the `source ~/.vimrc` command.

You can now declare each of the plugins you wish to use in the





~/.vimrc file. The declaration is in the format Plug 'foo/bar'. The code below shows how you can invoke the bullet list plugin:

```
#Lines beginning with a # are comments
#Plugins are mentioned between the call plug#begin line and the call plug#end() line
call plug#begin('~/.vim/plugins-placeholder ')
Plug 'dkarter/bullets.vim'
call plug#end()
```

You can declare many different plugins in the ~/.vimrc file. In the code above, since the bullets plugin is hosted on GitHub, we've used shorthand notation to identify the plugin we wish to use. You can alternatively also provide the complete path to the Git repository:

```
call plug#begin('~/.vim/plugins-placeholder')
Plug 'https://github.com/dkarter/bullets.vim.git'
Plug 'reedes/vim-lexical'
Plug 'reedes/vim-pencil'
Plug 'antenore/vim-safe'
call plug#end()
```

From inside Vim, run the :PlugStatus command and hit Enter. You'll see a list of currently installed and available plugins. Don't worry if none show up when you run it for the first time. With all the plugins you wish to use invoked in the ~/.vimrc file, run the :PlugInstall command from within Vim. This automatically downloads and installs the plugins mentioned in the ~/.vimrc file. When you run the command, Vim displays the installation status for each command on the left pane of the screen, while the right pane displays the ~/.vimrc file. Hit q to return to editing the ~/.vimrc file.

As with most command-line utilities, the different commands, such as :PlugInstall etc. are case sensitive.

You can check the status of the installed plugins by running the :PlugStatus command from within Vim or by navigating to your plugins directory. All installed plugins will get populated in the directory specified in the call plug#begin line of the ~/.vimrc file.

Updating and removing plugins

A major advantage of using plugin managers such as vim-plug is that you don't have to chase after updates for each of your different plugins. A single command can be used to update all the plugins at once.

From within Vim run the :PlugUpdate command, and vim-plug will fetch and install updates where available. Run the :PlugDiff command to inspect the changes made to each of the plugins by their respective updates.

To delete a plugin, you can either comment out the relevant Plug command in the ~/.vimrc file, or delete it entirely. Next, source the ~/.vimrc file again with the :source % command, and finally run the :PlugClean command. You'll be prompted to confirm if you wish to delete the plugins. If you don't want to be prompted for a confirmation and instead want the plugins to be purged straight away, you will need to run the :PlugClean! command.

A shortcoming of the vim-plug plugin manager is that it can't resolve dependencies. This means that you have to also declare each of the plugins that a plugin might depend on in order to provide all of the functionality.

Zen masters and command-line ninjas such as this author have a lot in common. Our task is just to show you the path. It's for each young Padawan to decide to take the journey on their own. Perhaps the author has spent too much time immersed in pop culture to make sense, but you will have to decide for yourself which plugins to use, depending on the features you want most in your text editor. ■

QUICK TIP

Any mention of running a command beginning with a : implies that it needs to be run from within Vim, and not from your terminal. You can simply launch Vim, and execute the :PlugClean and the :PlugStatus and the other commands as mentioned in this tutorial. modules as you need them.

Plugins repository

If you've been paying attention to the different blocks of code, you'll notice that we've mentioned several different plugins already. But how do you decide which plugin is best for you, or even if one already exists for a functionality you want in Vim?

Head over to Vim's website (**www.vim.org**) and click Scripts > Browse all on the sidebar. This brings up a list of all the plugins. Navigate to the bottom of the page, and you can now use the type drop-down list to choose which sort of plugin you're looking for. There's only a limited number of options, however, such as games, indent, syntax, utility, etc. You can also sort the narrowed-down plugins by creation date, number of downloads, and rating.

The other option is to point your browser to Vim Awesome (**https://vimawesome.com**), a user-contributed repository of some of the best plugins across different categories, such as Language, Completion, Code Display, etc. Each of these are in turn split into different categories to help you narrow down the plugins that might best serve your needs. The search bar at the top can also be used to look up plugins. Clicking on a plugin shows up all the relevant information, such as when the plugin was created, last updated, links to its homepage, and even installation instructions.

Sensor-triggered Telegram alert system

Les Pounder reveals how we can get data and control the Sense HAT add-on board using super-easy Scratch 3.

In this month's tutorial we will be creating a project that will alert us to any movement via a passive infrared (PIR) sensor. This will trigger a message to be sent to a service called IFTTT, which is used to receive inputs from various other services and then send outputs to other services. This message to IFTTT will trigger an output and image to be sent to a Telegram account alerting us to an intruder.

With the Raspberry Pi powered off, connect the PIR sensor to the GPIO using the three jumper wires. Connect GND to GND, VCC to the 5V pin of the Raspberry Pi. Lastly, connect the output pin of the sensor to GPIO17 of the Raspberry Pi. Now connect the camera to the CSI port, just next to the Ethernet/USB ports. You will need to gently lift the plastic clip and slide the cable in with the blue tab facing the USB ports. Then secure the cable with the plastic clip. Ensure that the camera does not touch the Pi at any time as it may cause a short circuit.

Power up your Pi and from the main desktop go to Preferences > Raspberry Pi Configuration and once there click on the Interfaces tab and enable the Pi Camera interface. When prompted reboot and wait for the Pi to return to the desktop.

YOU NEED
- Any Pi
- Keyboard/Mouse/Power/HDMI
- Raspbian
- Official PiCamera
- PIR movement sensor
- 3x Female to female jumper wires
- Code: **https://github.com/lesp/lfx262/archive/master.zip**

Software setup

On the Raspberry Pi, open a web browser and visit **https://web.telegram.org** and create a new account. Keep the Telegram web app window open, as this will be used to debug and view the output of the project.

Now open a new browser window/tab and visit **https://ifttt.com** sign up for a free account. IFTTT stands for IF This, Then That, and it is used to trigger actions based on inputs. In this project we will create a webhook, a real-time link from our code to the web that will trigger a message on Telegram that alerts us about an intruder.

To create the trigger, click on your account avatar icon in the top right of the screen, then select Create. Now click on If + and type in webhook, and click on the blue icon to launch. In the next screen click on Receive A Web Request, and then on the next screen give the event name as "trigger", without the quotation marks. Next, click on Then + and search for Telegram. Click on the selection and then click on Send Photo as the action. In the next screen the target chat should be with @IFTTT, however, as this is the first time we have used it we need to connect IFTTT with Telegram – just follow the process and it will connect up. Once connected it will take us back to the previous screen, so ensure that the target chat is with @IFTTT and then in the Photo URL section click on Add Ingredient and select Value1. Ensure that Value1 has a capital V. In the Caption section, change the caption to "Movement detected" and then click Create Action, then on the next screen click Finish to create and start the service.

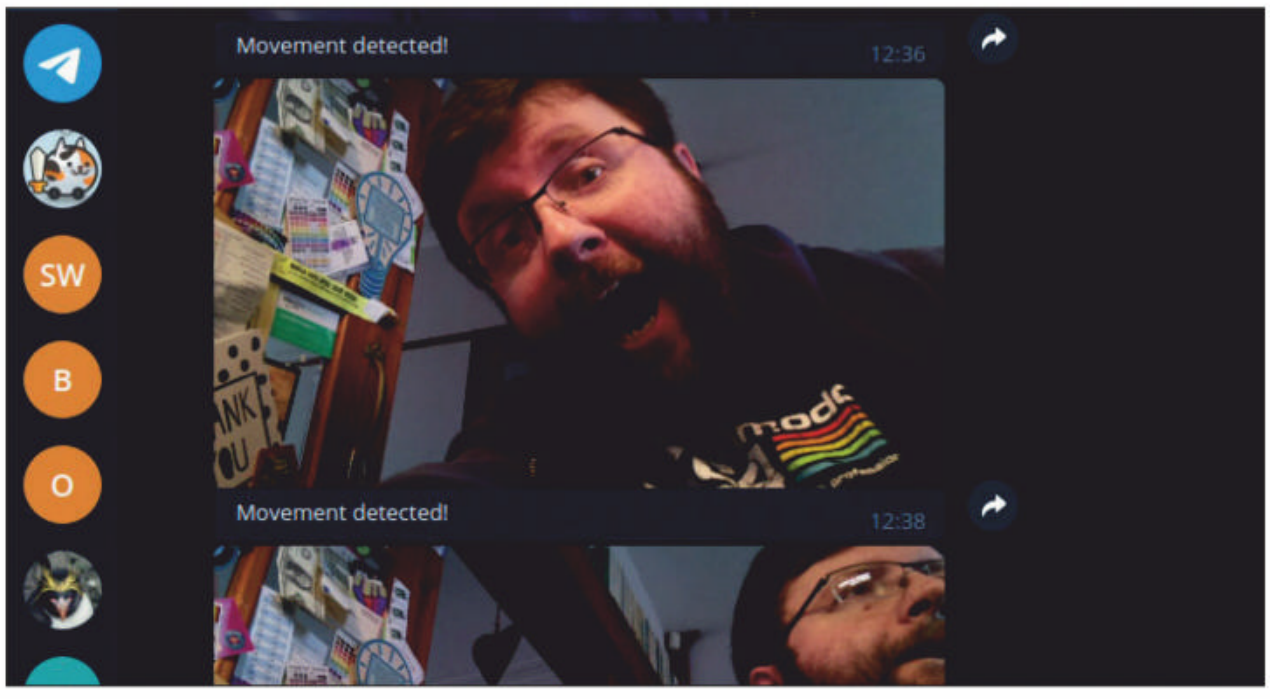
Now click on Home, and in the Filter services box type Webhooks and click on the filtered icon. In the next screen click on Documentation and you will see how the webhook is constructed. In the Make a POST or GET section click on {event} and change it to trigger. Now on the bottom line, which starts curl -X POST, select from https to the end of the line, then copy the link and save it in a notepad for later use. When you're done click < Back to service.

The last step in the setup is to create an account with **www.filestack.com**, which will be used to store images uploaded from the Pi. These images are then attached to the Telegram message. Sign up for a free account, and when logged in to the Dashboard your API key will be in the top right corner. We will need this later.

To use filestack with Python we need to install the library. In a terminal type the following and then press Enter to run:

```
$ sudo pip3 install filestack-python
```

Then close the terminal.



Telegram is a great real-time communications tool, and here we are using it to send images from our Raspberry Pi sensor trap!

Coding the project

To write the Python code for this project, choose your favourite Python 3 editor – we used Thonny – and create a new file called trigger.py. Remember to save very regularly.

The first block of code consists of the imports for the libraries that will make up the project. Requests is used to send a webhook to IFTTT. The `gpiozero` library is used to interface with the PIR sensor. The `picamera` library is for the camera, pause from `signal` is used to stop the

project closing after it runs. Lastly, filestack is used to send camera images to the service.

```
import requests
from gpiozero import MotionSensor
from picamera import PiCamera
from signal import pause
from filestack import Client
```

Next, we will need to create an object called client, which will contain a link to Filestack, including our API Key.

```
client = Client("YOUR API KEY HERE")
```

We now create an object to work with PiCamera, and then set the resolution of the camera to 1920x1080.

```
camera = PiCamera()
camera.resolution = (1920, 1080)
```

Onwards, and the next step is to create a function called send_alert, which will contain all of the steps necessary to send an image via webhooks to IFTTT and then to Telegram. When the function is called, the first step is to take a picture and save it as image.jpg, which is then uploaded to Filestack as a new_filelink. This is then printed to the Python shell for debugging.

```
def send_alert():
    camera.capture("image.jpg")
    new_filelink = client.upload(filepath="image.jpg")
    print(new_filelink.url)
```

To send the image to IFTTT we need to use the requests library to post it to the webhook address that we made a note of earlier. This link contains our trigger word, trigger and our API key for IFTTT, but it also contains a small section of JSON, which contains the key "value1" that IFTTT expects as the URL for the photo. So the value attached to that key is the new_filelink.url object, the URL for the image on Filestack.

```
r = requests.post("https://maker.ifttt.com/trigger/trigger/with/key/YOUR API KEY HERE", json={"value1" : new_filelink.url})
```

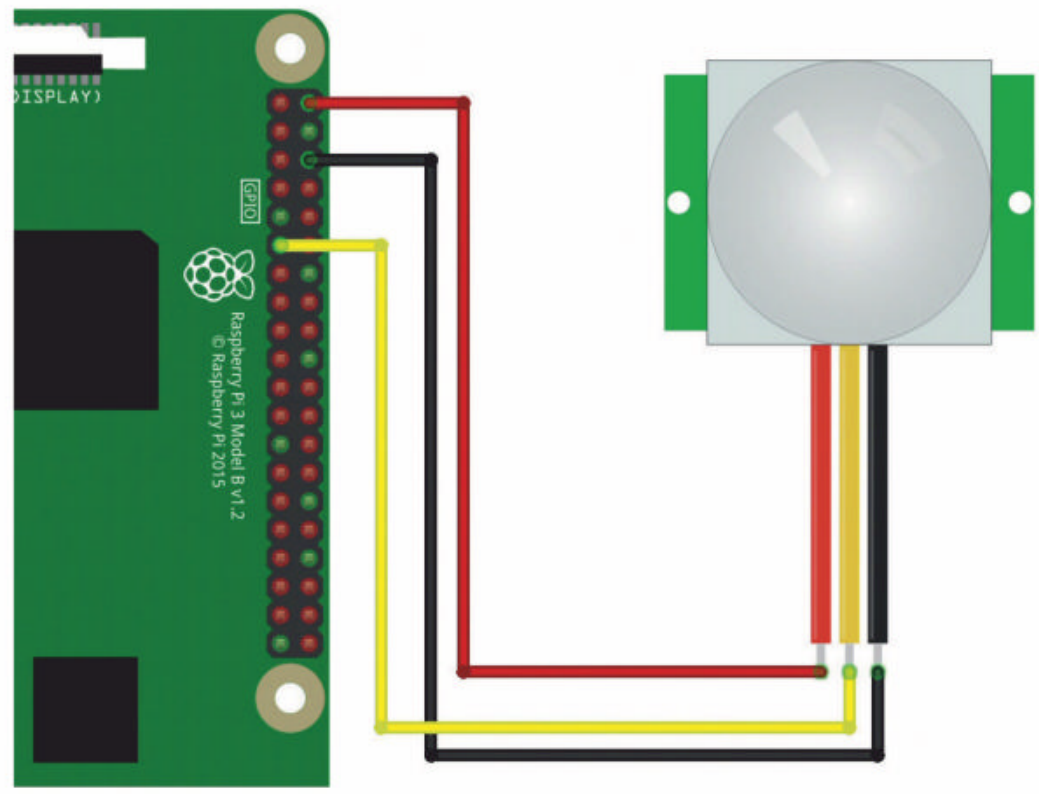
To handle any errors when sending the image we use the requests status code feature to query the returned code. If it is 200 then all is well, while anything else will trigger an error.

```
if r.status_code == 200:
    print("Alert Sent")
else:
    print("Error")
```

The function is now complete and here are the final three lines of the project. We create an object called pir, and in there we tell Python where our PIR sensor is connected, GPIO17. Then we tell the code that when motion is detected, it should load the send_alert function that we have just created. Lastly, the code should pause and wait for the next trigger to set off the alarm.

```
pir = MotionSensor(17)
pir.when_motion = send_alert
pause()
```

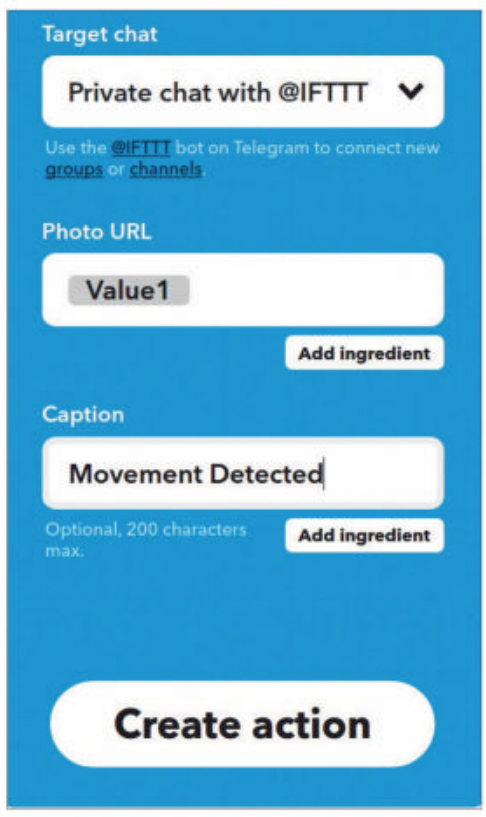
With the code completed, save and run. You should now be able to set off the sensor by moving your hand across it. Please note that it is very sensitive, so point it away from yourself for testing. Each time the sensor is triggered, the camera will take a picture and post it to Telegram – no matter where you are in the world, you will be alerted! ■



Here is how the passive infrared sensor should be connected to a Raspberry Pi. After setting it up, you can receive alerts and images of detected movement from anywhere in the world!

QUICK TIP

In our Python code the webhook URL has a section of JSON used to communicate the image URL as value1. In Python "value1" has a lowercase v, but in IFTTT "Value1" is used with an upppercase V. They are both the same.



To send a message and photo to Telegram we need to send it to our chat with @IFTTT and the Photo URL is Value1, a value passed from Python using JSON.

Webhooks

Why are webhooks so important? In this project we used a webhook to trigger IFTTT to send a message to Telegram. We didn't need to install a library for IFTTT, we just told the web interface who we were (API key) what our trigger was (trigger) and we passed it an extra value encoded in JSON (JavaScript object notation) that contained the URL for the image. The simplicity of just sending a message via the requests library's post function means that a webhook can be sent on even the lowest spec hardware.

There is a version of requests for MicroPython (urequests) that can send the same message to IFTTT. There are also methods to achieve this with Arduino boards. We can leave a sensor running on an Arduino/ESP32 in the field, and have it send data to a remote device, server or service via a webhook containing JSON. The uses for webhooks are numerous and can be used in IFTTT, Zapier or other projects. With Zapier we can connect our device to other applications and gather data. For example we could use a webhook to send a message to a Slack channel. So webhooks are a simple if often overlooked method that are well worth further investigation.

POWER SUPPLIES MASTERCLASS

PSU102: The strong 'silent' power type

Darren Yates continues his short series on PC power supply units, this month looking at the physical connections and whether or not it's worth being a fan of 'silent' PSUs.

Last month, we looked at the basics of PSU ratings and how wattage is the prime rating we typically use to determine whether or not a particular unit suits a PC build. However, beyond the basics, looking at watts to compare models is a bit like comparing cars on the size of their engine – it's important to some, but it doesn't tell you the whole story. This month, we delve deeper, looking at the practical issues of cabling and noise.

Mod your 'larity'?

Your average PSU will have a three-pin IEC socket to handle the standard PC power cable we all have dozens of filling up a box in the garage. But on the other end of that PSU is a series of connections to various components in your PC – the motherboard, drives, and video cards for starters. These connections alone have started many an argument, particularly on how they should be cabled, anchored, sleeved, and sized.

The first question you'll decide is whether you're a 'modular' or 'anchored' kind of person. Anchored cabling means you get a bunch of wires pouring out of a big hole in the side of the PSU that cannot be removed or replaced. Whether you need all of them or not, you may be able to cable-tie them out of the way, but you cannot remove them – nor can you make them longer. The up-side is that anchored models are generally cheaper than modular PSUs as a result.

Cable modularity means the PSU has a series of dedicated sockets for user-removable cables to connect from the PSU to the PC components. The benefit here is that you only install the cables you need, which makes for a cleaner-looking system. It also helps keep the internal airflow of your PC case cleaner for a cooler, quieter system. However, there are also drawbacks – first, modular designs are inherently more expensive because of the extra connectors. The second is, from my electronics viewpoint, every connector represents a possible failure point, where a poor physical connection can result in a burned-out joint. The key to avoiding this problem is ensuring the connector fits correctly and sits fully in the socket – that way you get a better connection that shouldn't arc and burn out. However, PSU manufacturers use modular cabling as a high-end feature, so if you're looking for a higher-performance PSU, count on modular cabling as a distinctive factor.

One important benefit of modular cabling I've found is that it tends to be longer than most anchored cabling, which means for larger ATX cases, the cables more likely reach where they need to go. However, long cables can create their own problems (voltage drops at high current, for instance), so you never want them longer than is necessary.

The compromise is 'semi-modular' PSUs and these are on the rise. Here, the 24-pin

"Cable modularity means the PSU has a series of dedicated sockets for user-removable cables to connect from the PSU to the PC components."

Corsair's TX-M PSU series features a semi-modular cable design and layout.

motherboard connector is anchored but peripheral power is provided on modular connections. Again, you can pay more for these than fully-anchored models, but semi-modular PSUs can be a better compromise, provided they fit your build and budget.

Silent running

Using traditional cooling designs, PCs generally require at least three physical fans for cooling – one on the CPU, at least one on the video card, plus one in the PSU. The vast majority of PSUs require a cooling fan to keep the active electronic components cool during operation. The harder you push the PSU, the faster the fan spins and the more noise it makes.

One of the key factors to do with fan noise is the linkages or 'bearings' between fan and fan motor. The cheapest and comparatively-least reliable are standard self-lubricating sleeve bearings. However, they're not as bad as that sounds and are used in millions of applications. It's just that if you buy a cheap fan, it'll likely have sleeve bearings. Ball bearings, which are a series of small balls rotating between the two cylindrical surfaces, last longer but are a bit noisier. Top prize goes to fluid-bearing (also called 'fluid-dynamic bearing') fans that use fluid as a cushion between the two surfaces – they last a long time, create the least amount of noise, but mostly appear in the top-drawer PSUs.

Most PSU are 'active'-cooling types – they electronically control the speed of the fan depending on the electrical load. The lighter the load, the slower the fan spins and the quieter it is. While that's good from an efficiency viewpoint, a continually varying fan speed can be a pain in the rear from a concentration viewpoint. What's more, in most cases, you don't have any control over it either.

Fan-less 'silent' PSUs

It's also the reason why so-called 'silent' PSUs continue to gain interest – at least until buyers see the price per watt. A silent PSU can be one of two types – a PSU with a built-in fan that only operates if the electrical load exceeds a certain percentage (eg. 20%) and is otherwise silent, or the type with no fan at all.

The EVGA 500B delivers lots of cable, all anchored to the PSU internally.

Having no fan is the ideal since there's no noise. However, passively-cooled or 'true-silent' PSUs are harder to make – that's because it's easier to hide away design compromises behind a decent fan. The only way a no-fan PSU can be cooled is by extremely efficient design, a decent amount of heatsinking and good air-flow. A heatsink is block of metal (copper and/or aluminium) with weird-shaped fins that thermally connects to active components (eg. CPU, MOSFETs etc). These fins help draw away heat from the components and expel it faster. You may find silent PSUs are heavier than fan-based models as a result.

As we alluded to before, silent PSUs are the most expensive per watt of all PSUs, because of the higher-quality design and components required to deliver a reliable product. If using a silent PSU, airflow and ventilation are crucial, so you can't put the PC case in a cupboard for example.

Think before you spend

These are some of the things you should consider when building your perfect PC. Don't under-estimate the noise a poor-quality PSU can make, otherwise you may literally never hear the end of it. Next time, we'll graduate to 'PSU201' and start delving deeper into issues of efficiency, power factor and go all Gold, Silver and Bronze. ■

Seasonic's CORE GX series includes a fully-modularised cabling setup.

DOWNTIME

Tokyo Game Show cancelled due to coronavirus

THE DAMN VIRUS RUINS ANOTHER COOL EVENT.

Tokyo Game Show will not go ahead this September, its organisers have confirmed. The 2020 event was scheduled to take place between September 24-27, but like E3, Computex, and Gamescom, that will no longer happen due to the COVID-19 pandemic.

"Due to the outbreak of novel coronavirus on a global scale and the situation remains unpredictable in Japan as well, the organiser and the co-organisers have reached this decision after a long consideration to place the utmost priority on the health and safety of visitors, exhibitors and stakeholders," the statement from the Computer Entertainment Supplier's Association reads. The Tokyo Game Show is one of the world's premier games industry conventions, and has occurred annually since 1996. In 2018, the show attracted nearly 300,000 attendees to its Makuhari Messe venue.

Elder Scrolls 6 is still "years" away, stresses Bethesda, so don't expect any new details soon

BETHESDA CONFIRMS IT WON'T REVEAL NEW *ELDER SCROLLS 6* DETAILS UNTIL "YEARS FROM NOW".

In response to a question asking about the status of the game on Twitter, Bethesda's SVP of global marketing Pete Hines firmly ruled out offering any further reveals about *The Elder Scrolls 6* anytime soon, stressing that fans need to temper their expectations for any new information about the upcoming RPG sequel, slated to hit next-gen consoles the PS5 and Xbox Series X sometime in the distant future.

GAMING NEWS

Tencent takes over *System Shock 3*

Mighty Goliath gets its hands on a classic remake.

System Shock 3 has been in development at OtherSide Entertainment for several years, but things started to look a little iffy earlier in 2020. Key staff have either left or been laid off, including senior designers, lead programmers, and more. Despite assurances in April that the project was still underway, OtherSide dropped a bombshell in May: Tencent has taken over development.

"As a smaller Indie studio, it had been challenging for us to carry the project on our own," a spokesperson for OtherSide wrote. "We believe Tencent's deep capabilities and expertise as a leading game company will bring the franchise to new heights."

Tencent is a true Goliath in the games industry. The Chinese conglomerate owns Riot Games (*League of Legends*) and Funcom (*Conan Exiles*) among many others. It also has a 40 percent ownership of Epic Games (*Fortnite*) and five percent ownership of Activision Blizzard. While the company is ubiquitous, it certainly comes as a surprise that it was getting involved in a relatively niche nostalgia project.

That said, while Tencent will handle development of the series reboot, the *System Shock* IP itself remains the property of Nightdive Studios, which is currently working on a remake of the original.

Command & Conquer remasters will reinvigorate modding scene

Giving modders the Nod.

Command & Conquer Remastered Collection was released last month, bundling spit-and-polish versions of both *Tiberian Dawn* and *Red Alert*, each supporting 4K, and each boasting all of its expansions. But even better, is that the remaster's producer Jim Vessella has confirmed the source code for both will be available under the GNU General Public License 3.0. This will make modding the game very easy, but it also means that most existing mods for the classic games should work.

"It's worth noting this initiative is the direct result of a collaboration between some of the community council members and our teams at EA," wrote Vessella in a statement posted to Reddit. "After discussing with the council members, we made the decision to go with the GPL license to ensure compatibility with projects like CnCNet and Open RA."

Tony Hawk's Pro Skater 1 and 2 release date set for September

Both games are back in HD glory.

Tony Hawk's Pro Skater 1 and 2 are getting a modern re-release for PS4, Xbox One, and PC (via Epic Games Store) on September 4. After a string of teases from Tony Hawk himself and Summer Game Fest producer Geoff Keighley, the remastered pair was officially revealed during a livestream today. Vicarious Visions, which has handled other PS1 remakes like the *Crash Bandicoot N. Sane Trilogy*, has remastered both of the original Tony Hawk's games, and they really do look stunning in motion.

Keighley and Hawk discussed the new and returning features of both games with Vicarious Visions head Jen Oneal. *Tony Hawk's Pro Skater* 1 and 2 supports classic D-pad and modern analogue stick controls, and its Create-A-Park and Create-A-Skater modes have been greatly expanded through new options and online play that lets players share their creations. In addition to new levels, the original levels are also back, and on top of returning old-school missions like collecting letters and tapes, Oneal told *IGN* that "we've added more challenges to each of the levels that you accomplish."

Civilization 6 - New Frontier Pass is coming with new civilisations, leaders, and more

It's coming with free updates between packs too.

Civilization 6 is getting a season pass three and a half years after it first came out.

The Civilization 6 New Frontier Pass will bring a total of eight civilizations, nine leaders, and six game modes to *Civilization* starting this month. 2K Games and Firaxis say the new content will arrive in the form of six DLC packs rolling out every other month through March 2021, all of which will also be available for purchase on their own if you prefer.

The first part of the Frontier Pass, the Maya & Gran Colombia Pack, will add new leaders from the two civilsations as well as new city-states, resources, natural wonders, and even a new Apocalypse game mode.

Firaxis is keeping the specifics for the rest of the New Frontier Pass under wraps for now. However, everybody who purchases the pass will receive the *Teddy Roosevelt* and *Catherine De Medici Persona Packs* as a bonus, adding the "Rough Rider Teddy" and "Magnificence Catherine" variants for the two leaders.

Steam Summer sale dates leak, here's when the savings will begin

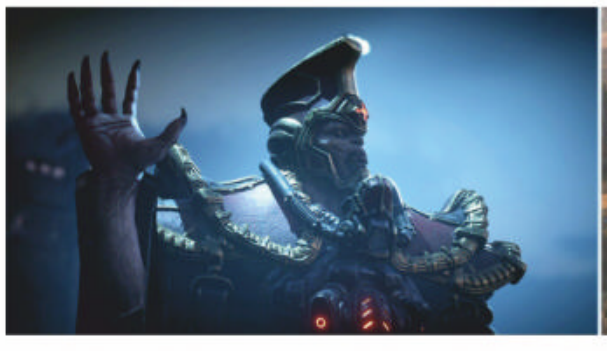
CHECK OUT OUR GUIDE TO WHEN THE NEXT STEAM SALE DATES WILL FALL.

The Steam Summer sale dates appear to have leaked ahead of time, giving you a heads up on when the next big round of deals will arrive. The leak this time comes from the creator and primary data miner behind SteamDB, who cites developer sources saying the Steam Summer sale dates are set for June 25 through July 9.

Disco Elysium goes low-spec

THE PEOPLE'S RPG.

Disco Elysium is the kind of RPG that is well-suited to playing on a laptop, but preferably not an oversize gaming laptop. Developers ZA/UM seem to get this, because last month they patched the game so that it will run on basically anything. And by basically anything, we're not exaggerating. If you've got a low-spec work laptop that's just itching for some R & R, it can probably run *Disco Elysium*. It's not just PC that gets the treatment, as most Mac units dating back to 2012 will now run the game. "We're going to try to keep optimising so low that we break through the crust on the other side of the planet," the ZA/UM's update reads. "Show us your scrapheap calculators and rusty adding machines and we'll give it a go. *Disco Elysium* for all!"



$99, PC, XB1, gearstactics.com

Gears Tactics

A strategy game worthy of the PC.

apc RECOMMENDS

Tactics has a linear campaign, told with very pretty Unreal Engine cutscenes. It's easily the best-looking tactics game I've played, and it's hard to oversell how precisely this game translates *Gears* into an overhead turn-based perspective. *Gears Tactics* is an aggressive strategy game that throws piles of enemies at you, because it knows you've got frag grenades that can turn a pack of scurrying wretches into chicken nuggets, or a chainsaw gun that has a 100-percent chance to slice even a full-health Locust in half.

While it first looks an awful lot like *XCOM*, *Gears Tactics* plays differently. Every turn in *XCOM* is about the tension of how few moves you can make. *Gears* is more freeform, giving each of the four soldiers you take into a mission three actions per turn. And every time one performs an execution move on a near-death enemy, the rest of the squad gets an extra action point for the turn, the design equivalent of a platoon shouting "Hoo-ah!".

You're not trying to make the best of your meagre options each turn. You're trying to extend your turn for as long as possible, every kill offering up the opportunity to earn more actions, until everything lies dead at your feet. I love how every turn pushes me to be creative with how I combine my squad's abilities.

The support class can gift an action point to a squadmate, and you can pair that with another ability that earns the support soldier an action back each time that squadmate gets a kill. It's like placing a bet on them and then trying to follow up. Each of the five classes have skills that combine in clever ways. The heavy, who carries a chain gun, can earn an extra action point for going into overwatch, making it the perfect defensive class. The vanguard can knock enemies out of cover, enabling you to keep pushing forward.

The skill trees for each class branch into four specialities, and you can freely choose how to mix those skills. Most of my characters ended up maxing out only one skill path, and as I recruited new soldiers that were specced differently I kept finding fun combos I hadn't used yet. Weapon customisation ties nicely into skills, buffing stats and even adding special effects like knockback. 'Legendary' rarity parts are typically rewards for difficult optional objectives and they're satisfying to earn, because you know they'll come with some big stat perks.

I got tired of the chase for more loot late in the game, but slap *Gears Tactics*' combat into a sequel with a couple more strategic systems that balance out the variety and pacing, and I'd honestly rather play it over *XCOM*, a recommendation I never expected I'd make.

WES FENLON

Clever combat abilities and brutal executions translate into a deep, fast-paced strategy game.

★★★★☆

$65, PC, supermegabaseball.com

Super Mega Baseball 3

A deep, multi-season bench.

The managerial aspects of the *Super Mega Baseball* series have always been a bit weak, but the outstanding new franchise mode in *Super Mega Baseball 3* lets you tinker with your roster over multiple seasons, wrestle with a salary cap, and presents you with far more situational decisions during individual games. Combined with several new on-field systems, *Super Mega Baseball 3* has added lots of depth and careful decision-making both on and off the field, while still preserving the arcade fun of the earlier games.

You can't trade directly with other teams in franchise mode, but you can sign free agents, kick players off your team, and best of all, develop your players' skills and attributes over time. During the offseason, young players join the league and older veterans leave it.

After each game in franchise mode you're shown a handful of players eligible for development, and you can spend cash to tinker with their skills: add a few points of hitting power, for example, or give a pitcher a bit more accuracy or velocity, sometimes at the cost of losing a few points from another skill. There's also a small chance a player will develop a situational trait during development. Traits can be good, like increasing the chance of contact when batting against left-handed pitchers, or bad, like a pitcher losing a bit of accuracy when they fall behind in the count. These attributes are small tweaks to a player's abilities in specific situations, but they make a big impact on the managerial side of things.

Super Mega Baseball 3 is the series at its best. The on-field baseball sim is livelier than ever, and player development, attributes, and free agency gives you some real managerial decisions to make both on the field, over the course of a season or seasons, and even during the offseason. *SMB3* may superficially look about the same as *SMB2*, but it's a whole new ballgame.

CHRIS LIVINGSTON

Adds loads of depth, decision making, and progression, and on-field play is a blast.

★★★★☆

Free, PC, bit.ly/FirstCutGame

First Cut

Channels the spirit of a Square classic.

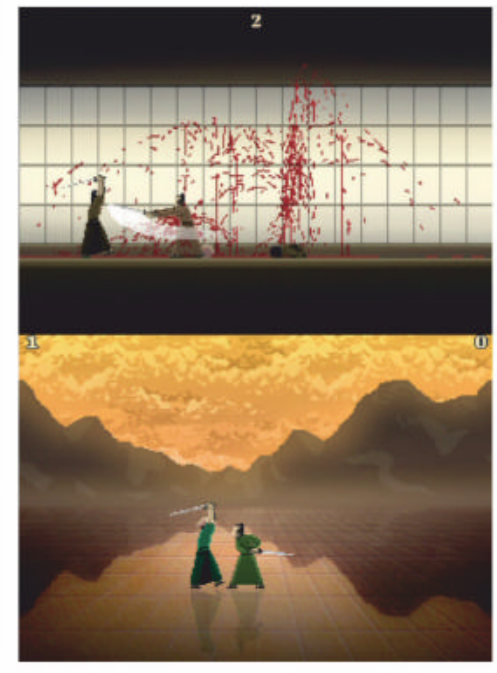
A few games have offered glimmers of the classic *Bushido Blade*'s essence in the years since its release, but the closest yet is *First Cut*, which is essentially *Bushido Blade* but in 2D. Duelling here is remarkably simple, but still replete with tactical possibilities. You have an attack button, which allows you to strike from on high, from a low angle, or straight in front of you. You can also dodge, by ducking down and darting behind, or dipping into the background. Slash your sword in concert to your enemy's attack and you'll parry it, and survive. Don't and you'll bear witness to a gory finishing move that will sever your head from your body, or chop you in half. It's a basic system, perhaps, but this is really all you need to create engaging blade bust-ups, full of immediate high drama, and with sudden endings to disperse the palpable tension.

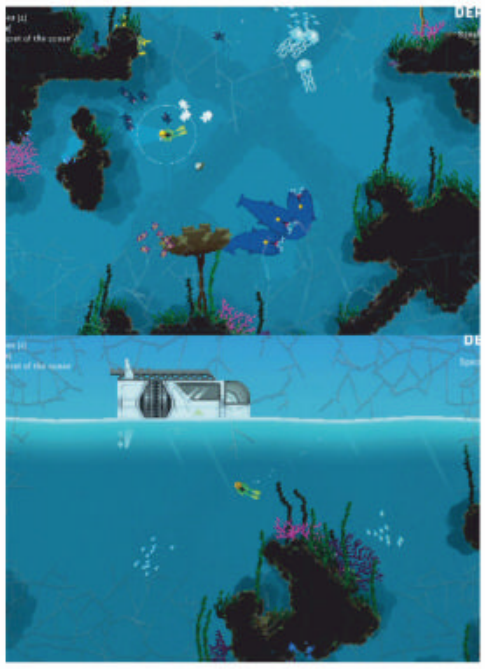
You can duel with a friend offline, or you can take on the computer, which I've found to be reasonably convincing.

TOM SYKES

A fighting game for people disenchanted with fighting games.

★★★★☆





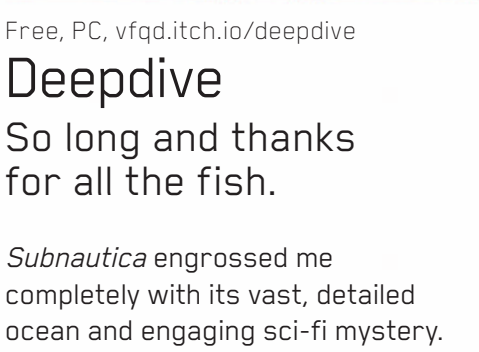
Free, PC, vfqd.itch.io/deepdive

Deepdive

So long and thanks for all the fish.

Subnautica engrossed me completely with its vast, detailed ocean and engaging sci-fi mystery. If you feel similarly, then you'll want to play *Deepdive*, which compresses its ocean down to a lake, while flattening it to two dimensions for good measure. There's no sense of mystery, unfortunately. In fact, there's no plot in this at all; just the sea and a diver eager to explore its depths. Your little diver feels suitably vulnerable as you propel them around a hostile, teeming ocean. Your ultimate goal is to descend to its deepest point, and to do that you'll purchase upgrades back at your lifeboat: you can enhance your speed, oxygen, inventory space, etc. Money is earned by scanning lifeforms, and by digging up precious gems. There's a satisfying if hasty progression loop and yet danger is never far away. *Deepdive* best echoes its inspiration. Its attractive, occasionally murderous sea is a place you'll want to explore. A place you'll simply want to be in for a while.
TOM SYKES

A pleasant and soothing underwater distraction.
★★★☆☆



$28, PC, XB1, PS4, Switch, ionlands.com

Cloudpunk

A story-driven delivery game set in a stunning voxel metropolis.

Whether it's *Blade Runner*'s rain-soaked Los Angeles or the planet Coruscant in *Star Wars*, there's something evocative about the image of a futuristic city criss-crossed with flying cars. And in the gorgeous, voxel-based *Cloudpunk* you get to be a part of one of those teeming skyways, driving a beaten-up hover car and delivering packages in a dystopian, multi-tiered city called Nivalus.

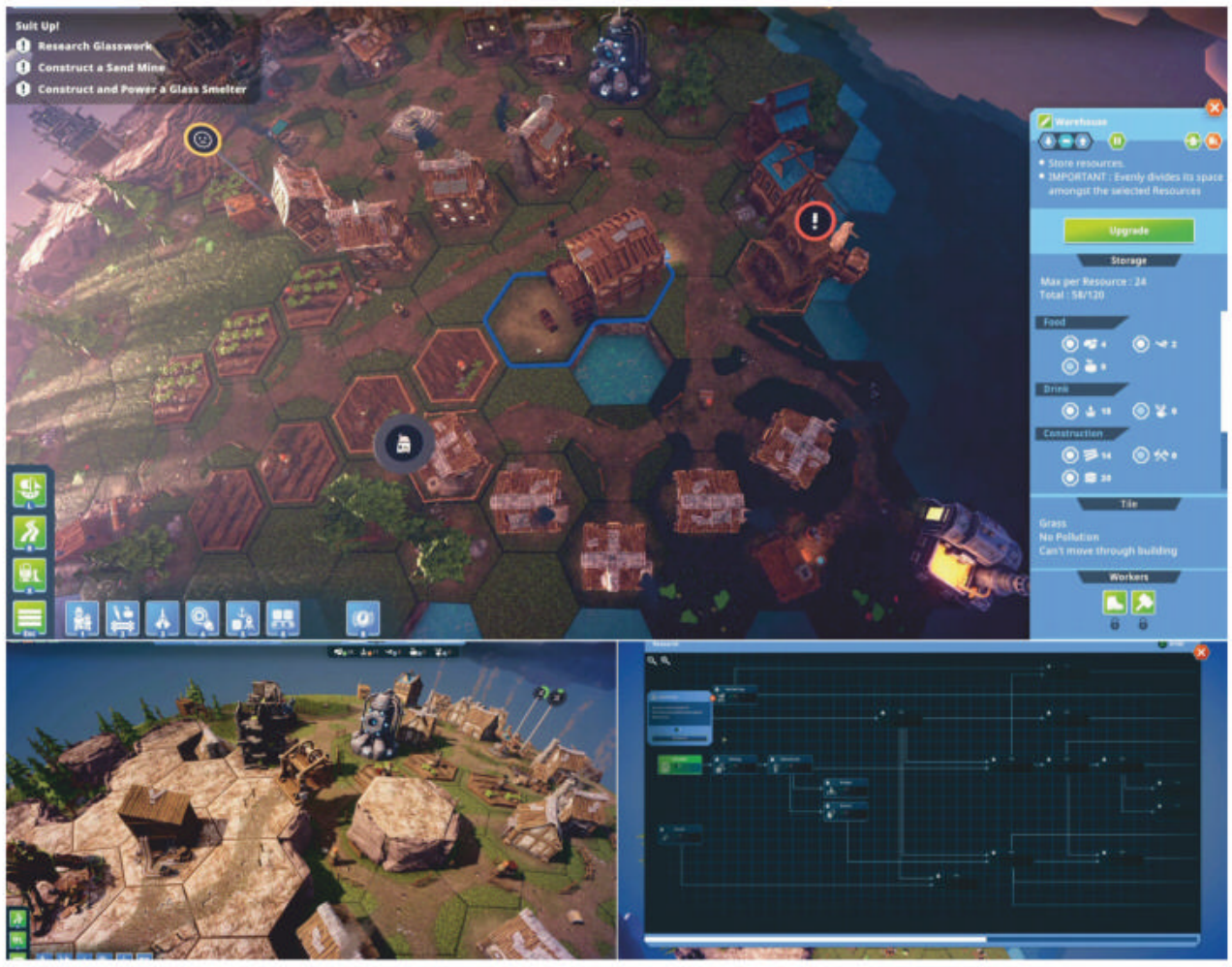
This vivid, intricate metropolis is genuinely stunning to look at. A bustling sprawl of neon signs, roaming spotlights, colossal billboards, and hover cars scurrying back and forth between monolithic skyscrapers. It looks great up close too. Lower your car to street level and you'll see pedestrians milling around noodle stands and seedy nightclubs. In the air: advertising blimps, trains streaking along suspended rails, and the glow of thousands of apartment windows. The sheer density of the place is remarkable.

You play as Rania, a newcomer to Nivalus who takes a job with a legally dubious courier company called Cloudpunk. Your job is simple: pick up packages, deliver them, and don't ask any questions. This is a game almost entirely about exploration and conversation. As you make your deliveries you'll meet a large cast of characters along the way, including shady nightclub owners, hackers, hover car racers, CEOs, cops, and self-aware androids.

There's a story to follow too. As Rania makes her deliveries she learns more about Cloudpunk, how the city is run, and the tensions bubbling beneath the surface. But what really holds *Cloudpunk* together is the driving. Or is it flying? Your little hover car is a delight to control, with a nice feeling of speed, weight, and momentum. Gliding across those cityscapes, weaving through traffic and firing your repulsors to gain altitude feels sensational.

Even if the story doesn't grab you, it's worth playing just to fly around that wonderful city.
ANDY KELLY

This vast, beautiful city is a joy to take flight in.
★★★½☆



$30, PC, balancingmonkeygames.com

Before We Leave

Takes extermination out of the 4X.

Space whales. It's a combination of words that leaps off the page at you, but the closest thing to an antagonist this gentle city-builder has aren't to be feared: they're only after your vegetables. *Before We Leave* is a non-violent city-building/4X game that wears its hexes proudly, a tiny bucolic sphere of them (plus 12 hidden pentagons to make it geometrically possible) hanging in the void whose inhabitants initially only know how to grow potatoes.

The citizens of your new civilisation emerge from the ashes of an old one – and it's a rather wonderful world to emerge into, all fertile plains and rocky highlands. Despite the occasional bit of wreckage from the prior owners of the continent before they nuked themselves into oblivion, the land is lush and forested. Deserts, rocks, ice, and the like are introduced later, but everything is covered in a splendid layer of hex-clouds that retreat and reshape as you spin the globe around.

The hexes may recall *Civilization*, but *Before We Leave* has more in common with small-scale games such as *Frostpunk*. There's none of that title's grimness here, though, and no micromanagement beyond the usual obsession with roads. You can spend time with the game on pause, plotting out a transport network, or you can go freestyle from the start, reacting to the need for growth by demolishing huts to make way for road access to the forest. Reduce peeps' travel time between an iron mine and the smelter, and you'll increase efficiency.

It's a refreshing change to play a building game, especially one with 4X tendencies, that doesn't act as a cover story for building up a mass of materiel and trying to nuke Ghandi. No roaming gangs of bandits will come broiling over the hill with their gimlet eyes set on your valuables – your vault must have been the only one. Even the aforementioned space whales are an annoyance rather than a society-ending problem.

IAN EVENDEN

A cute little city-builder with big ambitions.

★★★½☆

Free, PC, june-flower.itch.io

Remnants

Explore a collage of junk.

You play as a person who has decided to delve into a subterranean structure, for reasons hastily explained by the rather insubstantial ending. But let's cast that aside and focus on the other character, you: an archaeologist sifting through millennia of junk. Each level of the ominous structure brings a new themed floor of carefully designed rooms: one might look like an alien garden, another a game arcade, yet another an eerie temple from a horror story. Its arresting imagery is drawn from sci-fi, horror and fantasy – it's the scenery as plot, relating tantalising story fragments as you insist on interacting with simply everything.

There are (almost) no repeats, either of objects or their text descriptions, and a line of exposition for nearly everything you can see: every weird mural or doodad. I didn't feel a need to extrapolate a plot to explain this glorious heap of trash. I merely enjoyed sifting through it, delving down to see what sights were lying in wait.

TOM SYKES

Sifting through garbage is a great way to unwind.

★★★☆☆

DEVELOPER Harvester Games **PUBLISHER** Screen 7 **RELEASED** December 1, 2012 **WEB** bit.ly/2wmraLP

The Cat Lady

James Davenport on a game about despair and hope.

One of the best adventure games I've ever played kind of quits being an adventure game an hour or so in, and starts to blossom into a bizarre hybrid. It's a narrative game of two halves: one the story of a beautiful friendship between Susan, a depressed loner whose only prior company were the stray cats she summoned with sad-ass piano tunes, and Mitzi, a young homeless woman and terminal cancer patient. The other, a supernatural tale of eldritch horror and, above all, gory revenge against twisted, evil men.

As you can probably already tell, *The Cat Lady* sets all phasers to melancholy from the first minute, pairing up two of the most hopeless and unfortunate souls in order to show us that as long as we're still kicking, there's still time to love, baby. Because between pushing Susan through horrific scenes of violence and excess – we'll get to all of that later – she'll just hang out and chat with her bud. It truly is one of the better depictions of friendship in games. Mitzi breaks down Susan's guard with persistence and a keen ear, and by moving into Susan's flat against her will. Hey, that's what friends are for, right?

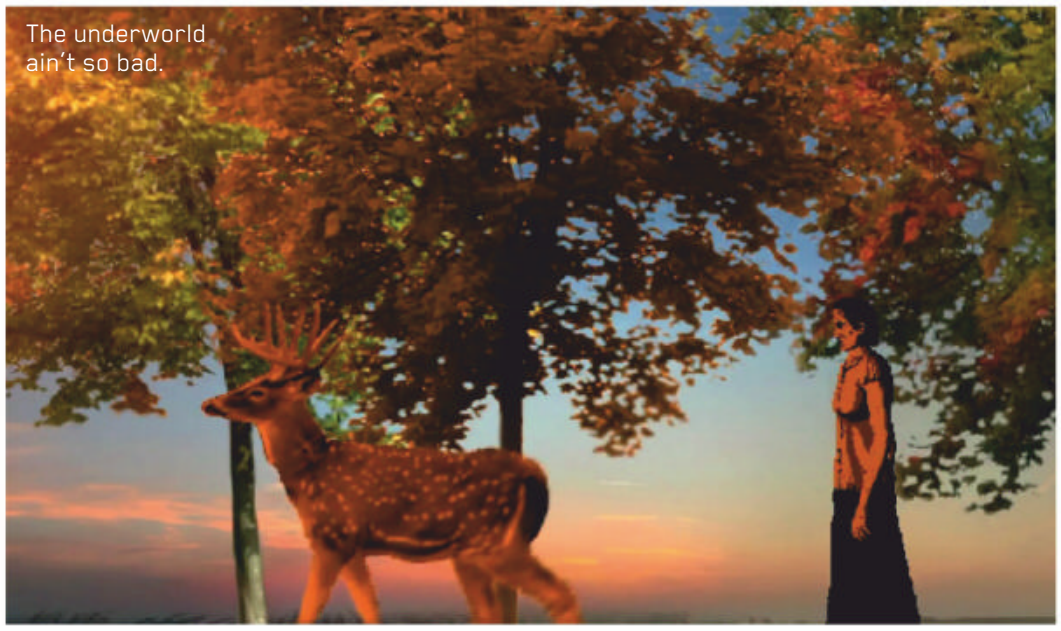
They chat to each other about things completely unrelated to their cosmic dilemma, finding common ground in their pasts, interests, and trauma.

It's a sweet, tender thing to see unfold, and rare in videogames, where friendship is so often treated with the dynamism of two stones brushing up against one another, and all that approach does for detracting from the narrative. Mitzi and Susan fight and cry and laugh and unravel as one. They move and change and grow together. It's the real deal, the sense of gravity in a game designed to unnerve and disorient at every other opportunity.

Paws for thought

All that gossip and teasing and confessional time with Mitzi is necessary downtime. As I teased earlier, you'll spend the other half of *The Cat Lady* playing as an immortal demigod whose only remaining purpose is to seek out irredeemably monstrous people and kill them in the most gruesome, thematically vindictive ways you can imagine.

But it takes a rough turn of events to get there. And yeah, quick content warning: this is not a game for the light of heart or anyone that wants to avoid triggering their own trauma. Suicide, depression, and abuse are central themes in *The Cat Lady*, and unabashedly explored. They're thrown at the wall and kicked around on the floor. If all the worst things about modern life coalesced like gasoline at the top of a mud puddle, *The Cat Lady* dances in it.


The underworld ain't so bad.


Probably not paint.


The doll's head is a nice touch.

See, Susan reaches the height of despair in the opening moments of the game. She makes the awful decision to end her own life, fuelled by a pile of traumatic experiences with family, men, and strangers. It's easy to see why she becomes such a misanthrope, so distrusting of everyone but herself and stray cats. But she's given something like a second chance, and wakes up in a dirty, stinky field (an afterlife I can believe in) where she's instructed by an eldritch horror with an extremely cool name, The Queen of Maggots, to return to the world of the living and brutally murder five psychopaths she lovingly refers to as parasites.

From there on the game basically becomes an inverse *Se7en*, where you already know 'what's in the box' and hunt down the crew of monstrous serial killers that put it there. And these killers get off by preying on innocents in some pretty unashamedly grotesque ways.

One, a male doctor, tortures women, disassembles them, and recreates classic paintings with their body parts. It's objectification taken literally, the patriarchal idealism of toxic masculinity run through a French brutalism filter (see *Martyrs*, *Inside*) and propped up for Susan to utterly demolish with her newfound supernatural power. As the details of her past trickle in, so does the catharsis from giving each parasite what they deserve. It's constant whiplash: the slow tour through a parasite's nightmare home, their messed up ethos splattered all over the walls, sometimes literally, and Susan's violent victory lap, an unkillable messenger from alt-hell.

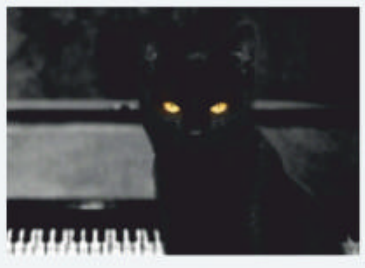
It's all accompanied by surreal, layered art that mixes a paper doll aesthetic with photography for a truly unique look. It begins with the blue and orange skies zooming by in the backdrop of a grey, monochrome hospital scene. There's the small detour to the Crow's dimension, another ancient eldritch entity that manifests here as a massive, darting eyeball against a dimly lit theatre. To leave, you only have to solve a riddle about which of the Crow's

MYTH BUDSTERS

Meet the deities of *The Cat Lady*'s weird underworld.

QUEEN OF MAGGOTS
Power over life and death, log cabin in underworld.

THE CROW
A massive eyeball and the master of riddles.



THE CATS
Not exactly what they seem – they're incarnations of spirits.

bear-sized, fish-eyed dolls is telling the truth. It's like one of *Monkey Island*'s wordplay puzzles, except all the jokes have been gutted and replaced with the feeling that something is very, very oh god so very wrong. Every scene is its own uneasy trip, a multimedia collage of colour and texture comprised of familiar images and materials that never quite sits right, even when *The Cat Lady* is at its most domestic. This is a grimy, serene world punctuated in equal parts by absolute stillness and graphic violence.

The puzzles shift from traditional item-hunting, trial-and-error tests to more of an interactive walking sim, where you occasionally set up *Home-Alone*-esque death traps for each of the themed murderers, ensuring they die writhing around in a pool of dramatic irony. As you play as Susan, you'll cobble together a mace from a doll's head and a buzzsaw, you'll use dangerous chemicals to asphyxiate even more dangerous men, you'll shotgun a man in a dreamlike home invasion, you'll don a gasmask and go on a full blown rampage. It's therapy, if therapy was about killing demented, greasy depictions of your demons. And even though you're going up against a crew of unfeeling butchers, there's no fail state or genuine threat to Susan – if she dies, she's resurrected immediately, thanks to her sort-of divine benefactor – so *The Cat Lady* is a great fit for those horror fans that don't like the high anxiety that comes with running from monsters in *Amnesia: The Dark Descent* or *Resident Evil 2*.

Im-purr-fect

But it hasn't aged perfectly. Parts of the soundtrack are laughably bad in the cold light of 2020 – that trashy fuzz emo rock you normally find in a *Devil May Cry* game doesn't quite find a home in a game that asks to be taken this seriously. As I replay the game, I find that kind of aged cheese endearing, but many will find it appalling. And the greater mythos doesn't always line up with the mental health themes or make much internal sense at all. For a fuller and more fleshed out take on it, you'll need to play the game's sequels *Downfall* and *Lorelai*. They each feature characters from *The Cat Lady* and really dig into what those eldritch bums the Queen of Maggots and the Crow, and some new freaky friends, are all about. There just isn't any videogame trilogy quite like this: dark, strange, and a little rough around the edges, but above all earnest and beautiful.

The Cat Lady is simultaneously goofy and sentimental, an exercise in justice and comic violence that doesn't always seem to match up with the dead serious subject matter. But it's a game ultimately about persistence against the pain of existing, and the fleeting bits of comfort and catharsis we find in our connections to one another, or the even smaller bits buried in the microscopic nodules of hope we're able to conjure up in our darkest moments. And if those nodules take the form of graphic revenge fantasies against genuinely, irredeemably evil people, I'll take 'em. ■

MACHINE OF THE MONTH

Sharp X68000 (1987)

The Atari and Amiga may have had their adherents, but when it comes to gaming, the Sharp X68000 is in a league of its own, as John Knight explains.

Dubbed "The God Computer" by the Japanese, the X68000 (or X68k for short) is perhaps the ultimate in 16-bit gaming. While console makers such as Sega and Nintendo often boasted "arcade-like" graphics, the X68k was the first home machine to provide genuine arcade graphics. The X68000 might not be famous in the West (it was only sold in Japan), but those in the know can expect near-perfect arcade ports.

However, X68k ownership is an eye-wateringly expensive proposition, with any half-decent disks costing several hundred dollars, let alone the cost of the hardware itself. For most of us, emulation is the only option. Nevertheless, it can be tricky to know where to start, and that's not even taking into account the language barrier of the Japanese operating system. So, let us do the hard work for you, as we explore The God Computer, the Sharp X68000.

History lesson

Launched in March 1987, the X68k was an intimidating machine. Although it shares the same Motorola CPU as its American counterparts, spec for spec, the X68k wipes the floor with its Western competitors, and was intended to dethrone NEC's PC-98 from its top position in Japan. Launching with a full megabyte of RAM (minimum) its CPU was 2MHz faster than the American's, and its sound chip was top of the line. It even had 1MB of VRAM. However, the price was as intimidating as the performance – around $10,000 in today's money.

Those who could afford the machine enjoyed essentially perfect versions of arcade megaclassics such as *Strider*, *Final Fight*, and the world-dominating *Street Fighter II*. This was hardly surprising, though, because the underlying hardware was already similar to that of arcade machines – Capcom even used the Sharp as a development machine for its arcade cabinets. The results were often genuinely perfect arcade ports, or at the very least, near-perfect ports with very little compromise.

The X68000's primary OS was Human68k – an MS-DOS-like operating system developed by Hudson Soft. On top of this DOS base were multiple desktop environments – like early versions of Windows on the PC – including Visual Shell, SX-Window, and Ko-Window. However, these interfaces were a kind of mashup between the Mac, Amiga, and NeXTSTEP operating systems.

Despite being known as a gaming platform, it was also marketed as a multimedia platform, with various packages for video, image, and sound editing, none of which were particularly famous. Although it was more than capable as a multimedia desktop (like the Amiga and ST), it was a gaming machine first and foremost. It even had a port for stereoscopic 3D goggles.

Gaming-wise, there's a ton of side-scrolling shooters – they actually make up a bulk of the Sharp's titles. Despite being famed for Japanese arcade titles, X68000 software is a mixture of East and West, with arcade classics and home micro titles from both the 8-bit and 16-bit eras.

Many will be surprised to find titles such as *Future Wars*, *Lemmings*, and *Xenon 2 Megablast*. As for Japanese cult gaming, try *R-Type*, *Cotton*, *Neural Gear*, and the jaw-dropping *Geograph Seal*. Especially famous among gamer geeks is a reworked version of *Castlevania* with a new engine, and upgraded visuals and audio, available only in Japan and only for the X68000.

The X68000 would be improved year by year, with the final machine shipping a standard 4MB of RAM, a 25MHz 32-bit 68030 CPU, and an optional 80MB SCSI hard disk. All kinds of upgrades were released, such as video accelerator cards, SCSI hard drives, and newer CPUs, but it was finally discontinued after 1993, when IBM-compatibles eventually dominated local Japanese systems.

YOU'LL NEED
32-BIT X86 CPU WITH MMX, WINDOWS 2000, OR LATER
Or you can use a solid version of Wine under Linux.

XM6 PRO-68K
Download it from **https://bit.ly/2TjiAF4**.

"Choosing one game would be difficult, but 1989's Final Fight is an all-time classic in both Japan and the West."

Collector Gary Pinkett shows us his popular black tower variant, running the SX-Window desktop.

Find software

While much of the X68000 collection is Japanese only, thankfully a lot of action titles are in English – or have at least enough English to make your way. Unfortunately, the Sharp's software library isn't as extensive as other platforms we've covered, nor does it have the same kind of modern hobbyist scene. Don't be dismayed, though – there is plenty of software on ROM sites (and more than enough to keep you going), we just can't legally point you toward most of it.

Retrostic.com claims to have a collection of software that is only out of production, and hasn't been hit with a big legal hammer yet, so it might be worth a try. **Archive.org** has an enormous 16.6GB software collection, as well as the "Gekkan Dennō Club Perfect Collection 1997." There are also user manuals, system ROMs, and community videos, so they can deal with any legal headaches!

For any interested users, the author of XM6 Pro-68k runs a software preservation archive, with a link on the XM6 Pro-68K website. If you have any disks to contribute, please get in contact.

Emulating the x68000

Although options such as MAME and RetroArch exist, we would prefer to use something bespoke. XM6 Pro-68K (**https://bit.ly/2TjiAF4**) runs nicely on just about any version of Windows and under Wine on Linux, and is well documented by its fastidious author.

Installation

The installation is slightly complicated due to some distribution issues, but things may be improved by the time this hits print. The website provides three zip files: the chief file is XM6 Pro-68k.zip, and is all that is technically necessary to run X68000 software. You need to extract the zip file and open the application (XM6.exe) manually from the main folder – if you plan on using XM6 Pro-68k a lot, you might want to make a desktop shortcut.

The second two files, XM6 Pro-68k DLL Package and XM6 Pro-68k Web Package, aren't system-critical but do enable updates and correct issues, such as missing fonts. To install the files, simply extract the packages into the main folder of XM6 Pro-68k.

Usage

On first boot, you're presented with a screen known to any X68k user: some Japanese writing and a picture of a floppy disk. The machine has no OS at this point, but most games you download (remember, you must have bought your own copy back in the day) include Human68k in their disk images.

Most disk images boot themselves, so try your luck by opening the main menu and choosing "Floppy Drive #0 > Open" and selecting your disk image. Floppy Drive #0 is your main drive, so run your disk images from this drive, and if your game is spread across multiple disks, open the first disk on Drive 0 and the second disk on Drive 1.

When games don't load automatically, you'll probably be stuck at Human68k's command prompt. Despite being Japanese, the OS uses English commands, and is similar to MS-DOS, except it uses a .X file extension instead of .EXE. If you've never used DOS before, don't panic.

To browse your disk's contents, enter the command **DIR**. The current directory will display, with filenames on the left and extensions on the right. You want to look for batch files with the extension .BAT, or executables with the extension .X – you should try running any batch files before running an executable. If your batch file has something like START on the left and BAT on the right, type START and press Enter. If your executable has something like GAME on the left and X on the right, type GAME and press Enter.

If you find yourself stuck at a game's intro screen, you may need to change the input method. This is found in the main menu under "Tools > Controller Mode." Some games and graphical environments use the mouse, which can be activated by selecting "Mouse Mode" or middle-clicking inside the main window.

Although most games can use the keyboard, they almost all use a different set of keys. To avoid a lot of trial and error, we recommend plugging in a USB joystick, which can be configured under "Tools > Options." ■

SPECIFICATIONS

Sharp X68000 (1987)
CPU Motorola 68000 @ 10MHz
RAM 1MB (up to 12MB), 1MB VRAM
Launch price ¥369,000 (around $5,225 today)
Graphics 65,536 colors @ 512x512, 64 colors @ 1024x1024
Sound Yamaha YM2151, eight-channel, FM synthesis, dedicated ADPCM
Storage 5.25-inch floppy, later hard disk upgrades
OS Human68k
Released March 1987
Production 1987–1993

YouTuber RetroManCave helping us out with his period-incorrect LCD pounding the legendary *After Burner*.

CHIP CHAT

JOEL BURGESS REPORTS ON THE UNUSUAL SIDE OF TECH NEWS

Programmer runs self driving car tech in *GTA 5*

Real autopilot software drives itself across Los Santos.

While the natural inclination in *GTA 5* is to rip down the road (or sidewalk) as fast as that rear-heavy Chevy you boosted from a grandma can go, if you play it long enough you probably had a go at trying to drive like you would in real life and it's not all that easy, at least for mere mortals. So we were impressed when we heard 15-year-old programmer Leon Hilman had adapted the Comma Two self driving car software to chaperone him around Los Santos. Considering the software already has 24 million kilometers of on-road experience, it's perhaps not all that surprising it can handle itself... now we just want to see how it handles with a four-star Wanted rating.

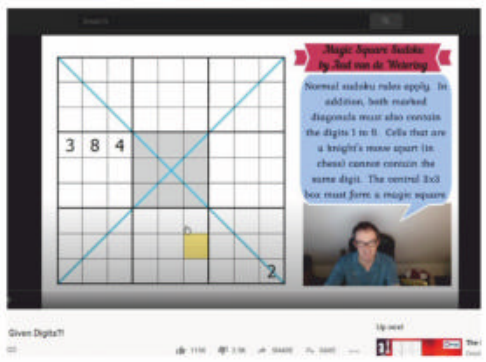
RDR2 is better than Zoom for work meetings

Red Dead Redemption 2 meetings allow you to enjoy outdoor meetings during lockdown.

Many of us hadn't heard of Zoom before the coronavirus lockdown, but it appears there's an even better app for business meetings: *Red Dead Redemption 2*. While it is undoubtedly easier to get distracted in the Rockstar shooter, it's also got some great campfires for group meetings according to illustrator Vivian Schwartz. Schwartz agrees that the initial setup of *RDR2* is a little longer than Zoom or *Minecraft*, but after switching all company meetings to *RDR2* she's noticed the ability to pour yourself coffee and communicate nonverbally using the in-game signals offers a more natural meeting vibe. If you really need a chalkboard (and your co-workers all have proper gaming rigs), then the new *Half Life: Alyx* is a good alternative, since it lets you write on glass with a marker.

AI learns the art of drawing dongs

AI has mastered X-ray medical scan examinations, legal clerking, and weather prediction, but there's one major milestone that took longer than usual for it to conquer – the critically important skill of drawing dicks. DickRNN, as this Picasso of recurrent neural networks is known, pored over 10,000 of the best doodle doodles humanity could muster to learn from the greats. DickRNN now knows how to draw penises of various sizes, complete with pubic hair (if requested).



Sodoku live streams attract millions of viewers

If you enjoy board games, you probably already know that during the most intense moments of the coronavirus lockdown they were almost as hard to come by as a roll of toilet paper. We suspect that this was (at least in part) the reason for the massive uptick in digital *Sudoku* popularity... an uptick so large that *Sudoku* live-streams became a 'thing'. As a non-Sudoku-er the concept of watching someone else do a puzzle feels like what you would be forced to watch if the *Big Brother* show decided to ditch all editing responsibilities. Yet YouTubers like Cracking the Cryptic have racked up over three-million viewers doing these numerical crosswords to captive online audiences. ■

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DrayTek Aust & NZ

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