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Credit: Getty Images/Damir Khabirov

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Microsoft combines Windows and Surface

Microsoft's latest reorganization isn't yet official, but it's likely to be announced soon. **MARK HACHMAN** reports

Microsoft is combining its Windows client and Surface teams into a dedicated unit led by product chief Panos Panay, according to a recent report, potentially aligning its operating system and PC hardware under the same roof.

According to ZDNet's Mary Jo Foley, the combination will be named 'Windows + Devices', and will be led by Panay. Joe Belfiore, who leads the Windows Experience team, will move over to the Office side of the house later in the year. A source close to Microsoft confirmed the report, though Microsoft's not confirming it publicly for now.

"Personally I'm very excited to lead the Windows Client for Microsoft, which will help us streamline our decision-making processes, be clear on our priorities, and deliver the best end user experiences from silicon through operating systems across all Microsoft apps and service connected devices (OEMs and Surface)," Panay wrote in an internal memo, as reported by Foley. "We believe this will make the Windows Client experience better for the entire PC ecosystem."

Surface + Windows: Unfair advantage?

The combination will align Windows and Microsoft's PC business even closer, in much the same way that Apple's software and hardware teams work closely together, or Google's Chromebook and Pixel teams talk to the Android and ChromeOS developers. That's worked out well for Apple, of course, and the Android ecosystem is thriving.

The PC industry, of course, is a much more fragmented and fragile business. A surprising jolt in sales during 2019 was immediately being followed by predictions of a corresponding drop once the industry navigated the transition from Windows 7 to Windows 10. Microsoft, meanwhile, saw its Surface sales grow to nearly \$2 billion (around £1.53bn) even

as company executives noted execution problems within the consumer Surface business.

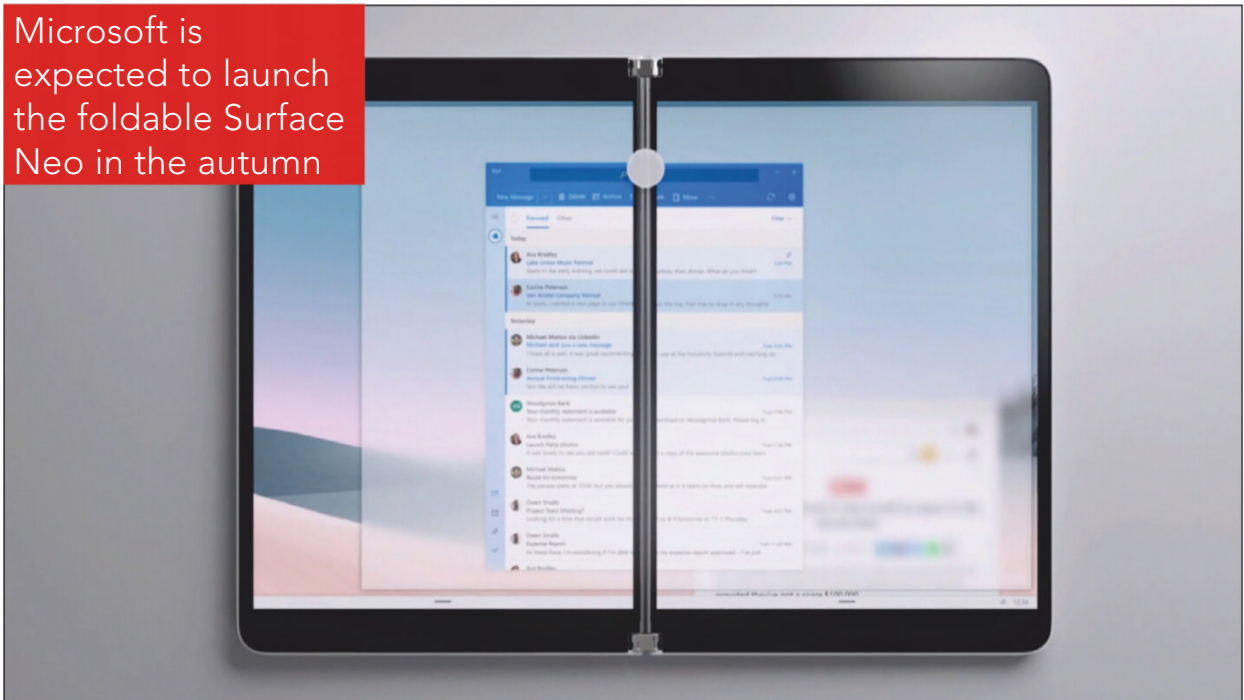
Obviously, the Windows teams and the Surface hardware group work at the same company, so a certain amount of collaboration would be natural. This does take it to the next level, however. Microsoft has traditionally synchronized its Surface announcements with corresponding updates within Windows, although it was really the October, 2018 Surface launch when Panay and Yusuf Mehdi, Microsoft's corporate vice president of what Microsoft then called Modern Life and Devices, overtly tied products like the Surface Pro 6 to collaboration, Office, and Windows.

PC makers worried that Microsoft was trying to take over the PC business when the tech giant launched the original Surface many years ago. In response, Microsoft positioned devices like the Surface tablet and the Surface Studio as trailblazers, establishing a market that PC makers could then fill out.

Of course, Microsoft's 'trailblazing' efforts haven't always led to a surge in similar products. Consider the Windows tablet market: the Surface Pro (2017), Surface Pro 6, and the recent Surface Pro 7 simply haven't faced much competition, as OEMs somewhat de-emphasized tablets in favour of more traditional clamshell designs. On the other hand, Microsoft will follow companies like Lenovo and its ThinkPad X1 Fold into the market with the foldable Surface Neo, due this autumn.

Does Microsoft's reorganization pose a dire threat to the greater PC industry? Of course not. But it might have a demoralizing effect on PC makers, some of which have to feel that Microsoft's moves make it

Microsoft is expected to launch the foldable Surface Neo in the autumn



tougher for everyone to compete. Microsoft's recent emphasis on the cloud – and in effect, away from the PC – likely fuels such concerns.

It will be up to Microsoft to make the case that the move benefits the PC industry as a whole, and not just Microsoft. We'll have to see what Microsoft says in that regard as it publicly spins its latest reorganization.



Microsoft's Surface sales near \$2 billion

But its Azure cloud business grew by an impressive 62 percent all by itself. **MARK HACHMAN** reports

Cloud, cloud, cloud, followed by Office, gaming, Surface and then Windows: by now, Microsoft has laid out its priorities, and the financial results Microsoft reported last month reflected this.

For consumers, the high point of Microsoft's fourth-quarter calendar 2019 results was the fact that Microsoft reported \$1.98 billion (around £1.4bn) in Surface sales alone – almost making Surface a \$2 billion

dollar business. Interestingly, chief financial officer Amy Hood implied that sales could have been higher, referring to unexplained “execution challenges” in the consumer portion of the Surface business.

Overall, Microsoft reported profits of \$11.6bn (around £8.9bn) during the second quarter of its fiscal 2020 calendar, up 38 percent from a year ago, from revenue of \$36.9bn (around £28.45bn), up 14 percent from the same period.

The More Personal Computing business that includes Windows, Xbox, and Surface still generates the most revenue at \$13.2bn (around £10.17bn). However, it reported just two percent growth – and that was better than expected, Hood said, due to strong Windows PC sales.

Microsoft’s growth is primarily being driven by the Intelligent Cloud business, and specifically Microsoft Azure. The Intelligent Cloud business recorded \$11.9 billion in revenue, growing by a whopping 27 percent. Within that business, Azure grew by 62 percent just by itself. In all, Intelligent Cloud once again edged out Microsoft’s Productivity and Business Processes (\$11.8bn, around £9.1bn) in terms of revenue.

Microsoft’s Productivity and Business Processes – Office and Microsoft Dynamics, plus related services – saw 17 percent growth, fuelled by 20 percent growth in Office 365 consumer revenue and 37.2 million consumer subscribers.

Uncertainty in consumer business

Microsoft’s MPC business faces more uncertainty than it has in the past. Revenue is expected to drop

fairly substantially during the first quarter, Microsoft said, due to a variety of factors. The first, of course, is seasonality: consumers buy far less during the first calendar quarter than they do during the holidays. Then there are flagging parts of the business, such as search advertising revenue, which dropped from 14 percent growth a year ago to just 6 percent.

Microsoft also acknowledged that the PC market supply chain is changing to adjust for reduced demand. The corporate PC market hastily bought new Windows 10 PCs in advance of the 14 January deadline that just passed, when Microsoft stopped supporting Windows 7. Windows OEM revenue in the current quarter might grow just by low to mid-single digits, Hood said. Overall, the MPC revenue outlook ranges between \$10.75- and \$12.05bn (around £8.29- and £9.29bn), a wider spread than normal. Hood called out the uncertainty of the public coronavirus health scare in China, too.

It's unclear what Hood meant when she predicted low single-digit growth for Surface as the company "works through challenges in the consumer segment". Neither Hood nor Microsoft CEO Satya Nadella explained whether Hood was referring to slower-than-expected sales in consumer Surface devices (versus Surface for Business sales), or whether Microsoft had designated certain devices like the Surface Go as specifically consumer products. (A Microsoft representative declined to comment further when asked to clarify Hood's remarks.)

Gaming revenue, which Microsoft said fell 21 percent, will be understandably slow at the moment.



Project xCloud has attracted 'hundreds of thousands' of users

AMD, the supplier responsible for the chips powering the Xbox One as well as the upcoming Microsoft Xbox Series X, said that SoC chip sales would be negligible for the near future. Xbox content and services fell 11 percent, Microsoft said, in part because of strong sales of games a year ago. As sales of the Xbox Series X begin to come in, however, revenue contributions will begin to increase during the second half of the year, Hood added. Nevertheless, Microsoft said it reached a new record level in Xbox Live users, and that GamePass subscriptions had doubled.

Microsoft's Project xCloud, allowing consumers to play games on a cellular phone directly from the Azure cloud, has attracted "hundreds of thousands" of users, according to Nadella.



Microsoft Surface Pro 7

Price: £1,449 (inc VAT) from fave.co/2PbZKPN ★★★★★

Microsoft's Surface Pro 7, the latest in the company's excellent Surface Pro series, continues the tradition of being a durable, dependable tablet for the ages. It's measurably better this time around, too, with an internal upgrade to Intel's 10th-gen, 10nm Ice Lake chip and a nod to the future, a USB-C port. There are many good reasons why we love the Surface Pro 7.

Microsoft's Surface Pro 7 virtually requires the a Type Cover of some sort, transforming it into a lightweight laptop



Granted, it's a lot easier to be the best game in town when rival Windows tablets are few and far between. At this point, the field consists largely of Microsoft's Surface Pro models, the Surface Pro X (£999 from fave.co/2vpqq7L), Lenovo's ThinkPad X1 Tablet (£1,559 from fave.co/37t2pKx), monstrous tablet workstations like the HP Zbook X2 (£2,504 from fave.co/38nSnvt), and our long-standing favourite, the Lenovo IdeaPad Miix 520 (£799 from fave.co/2Sn1CpR). There's a definite gap between these and £300-ish Atom-powered tablets from names like RCA and iView, which we wouldn't necessarily recommend. If you're looking for a full-fledged computer that's extremely portable and can even work as a tablet, the Surface Pro 7 is your best choice.

Hardware and specs

The Surface Pro 7 is a full-fledged PC made superportable. You won't get discrete graphics, but you will get CPU choices up to a Core i7, and generous RAM and storage options. Here are the full specs:

The Microsoft Surface Pro 7 offers the same tablet experience as in years past: prop it up with its iconic kickstand, connect the 'optional' Surface Signature Keyboard (that you'll want unless you're seriously tablet-centric), and get to work. A Surface Pen, as always, is optional. Though it's among the most portable of Microsoft's Surface offerings, the tablet isn't quite the mobile-forward design that you might have

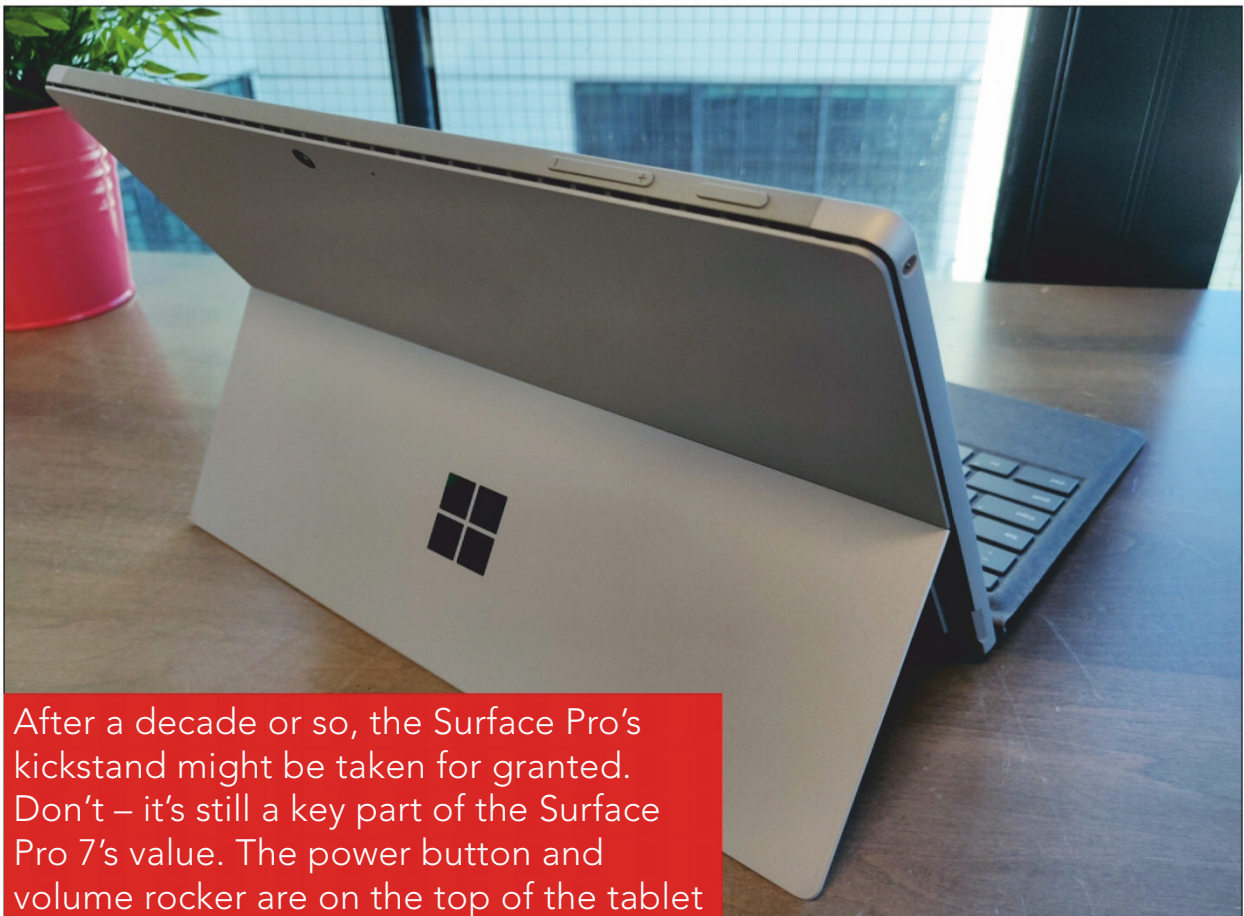


Yes, the Microsoft Surface Pro 7 is indeed a tablet

hoped – that's left to the Surface Pro X, though that tablet ships with its own set of issues.

Our Surface Pro 7 test unit shares an Intel Core Ice Lake processor with the Surface Laptop 3 for Business (£1,949 from fave.co/2SqXQfr), a substantial improvement in processing power from the prior generation. Traditionally, this has been what's separated one Surface Pro from its predecessor.

Versus a modern laptop or Android tablet, the Surface Pro 7's bezels are relatively enormous: about a half-inch along the left and right bezel of the device, and slightly less along the top and bottom. They're a necessary evil for enjoying the Surface Pro 7 as an



After a decade or so, the Surface Pro's kickstand might be taken for granted. Don't – it's still a key part of the Surface Pro 7's value. The power button and volume rocker are on the top of the tablet

actual tablet, and holding it by its edges. Still, the large, chunky bezels give it a rather dated look.

The built-in, glossy 2,736x1,824 display remains unchanged from previous models, slightly less than the true 3,000x2,000 resolution of, say, the Lenovo ThinkPad X1 Tablet (3rd Gen). Microsoft hasn't moved to OLED technology yet, unfortunately. The 396 nits of brightness that the display puts out is in line with that of previous Surface tablets, and not too far out of line with rival notebooks and tablets. It's still not bright enough for working in full sunlight, though, especially as the glossy display is very reflective. Inside my somewhat dim basement office, though, the Surface Pro 7 was a pleasure to work upon.

By the way, while Microsoft claims that users may be able to open the Surface Laptop 3 and upgrade the SSD, the Surface Pro 7 is decidedly sealed.

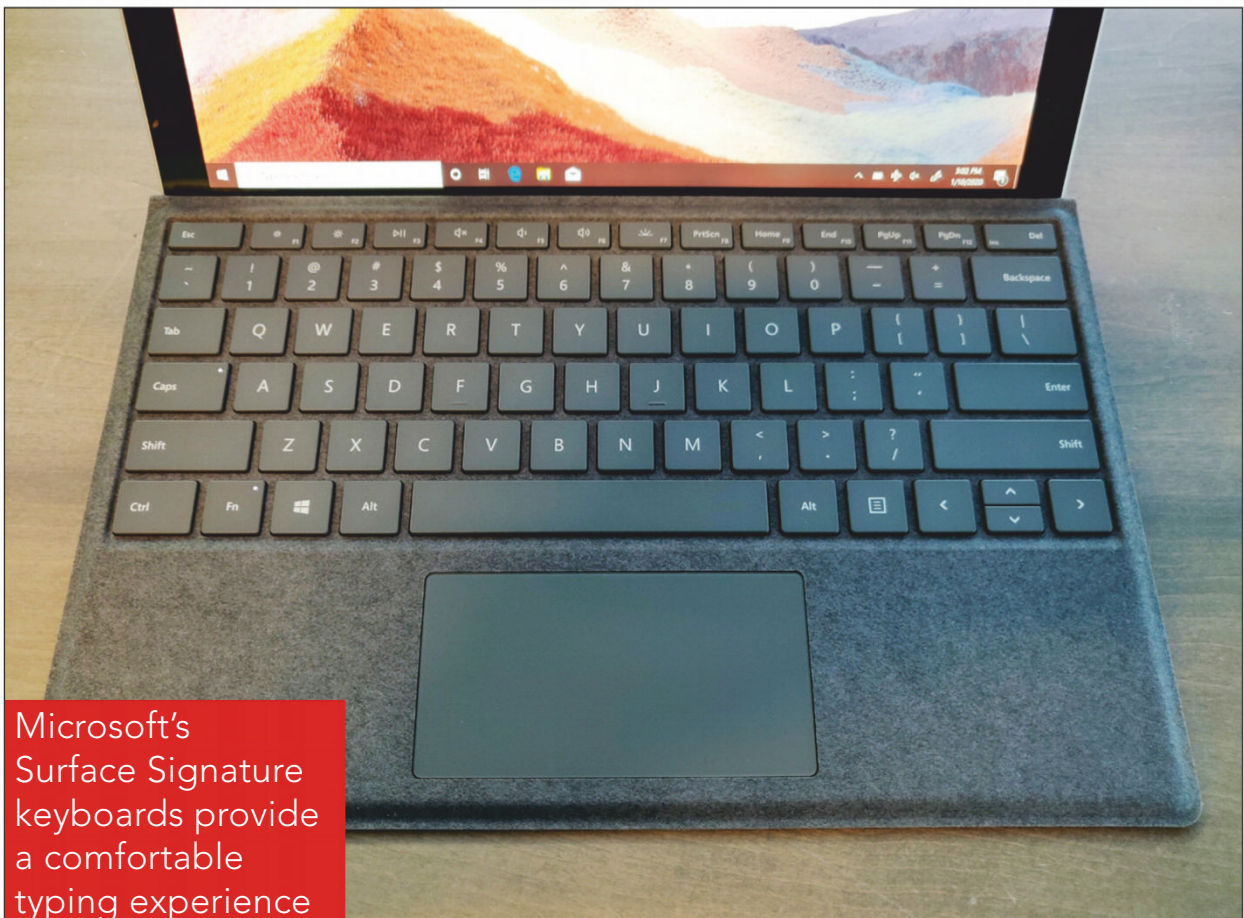
A solid keyboard and typing experience

As always, if you do buy the Surface Pro 7, be sure and budget for a Surface Pro Signature Type Cover, £149 from fave.co/37pPrge. Unofficially, you have cheaper alternatives: if you can track down the Surface Type Cover for the Surface Pro 3 (with a pen loop) or the Surface 3 Type Cover, they'd both work – I attached each in turn to the Surface Pro 7 and wrote a couple of paragraphs in this review. They rattle a bit, and the layout is slightly different compared to the more modern Signature Type Covers that begin with the Surface Pro 4. But they cost a lot less.

The older Type Covers feature larger keys, though with less key travel and resistance. In some ways,

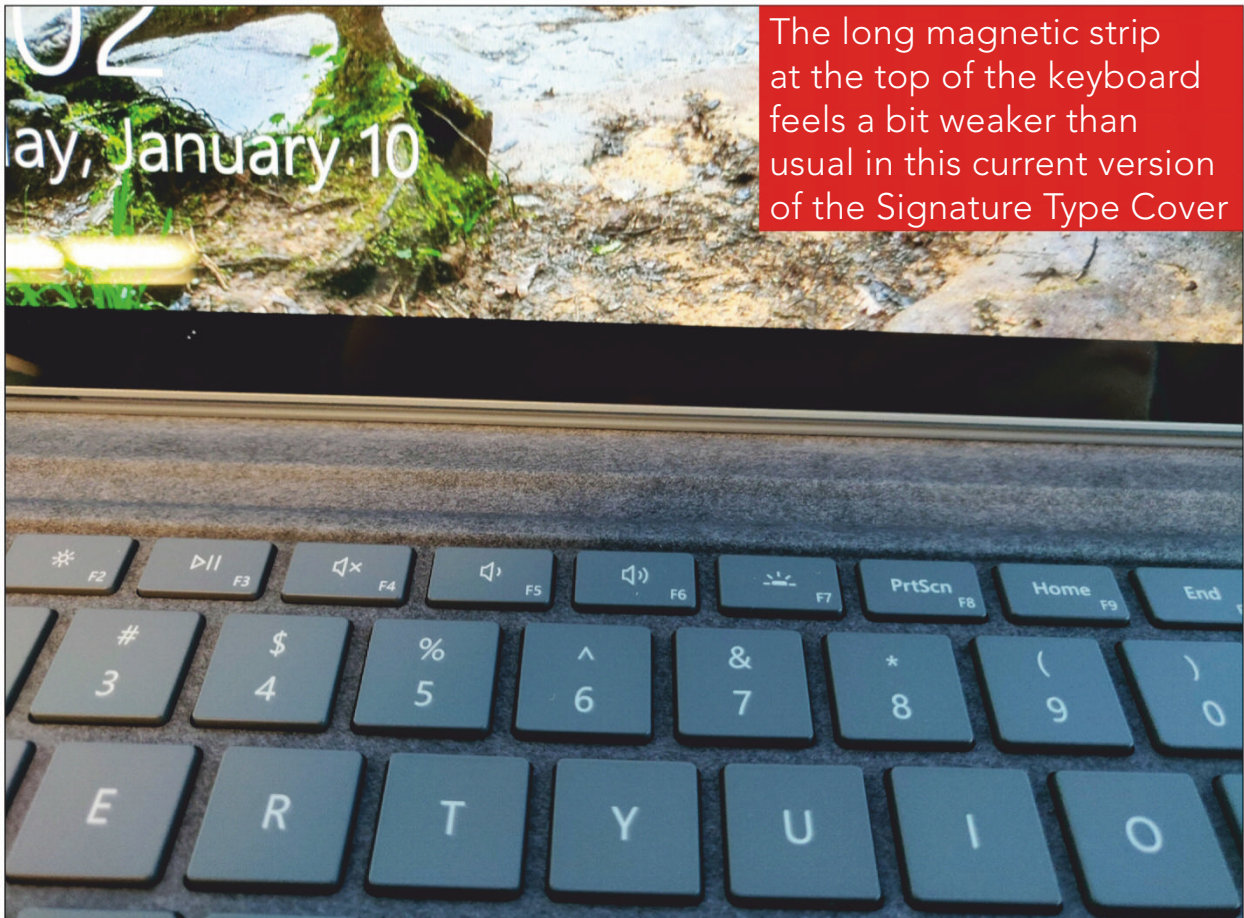
I prefer the older Type Covers, as there's a happy medium between the need to depress the keys and the desire to glide over them quickly. Over succeeding generations, the Type Cover's individual keys have shrunk, giving more room to the trackpad. Like any keyboard, however, the feel is subject to individual interpretation. The Type Cover also protects the Surface Pro's display. The more modern Type Covers feel a bit stiffer and more sturdy, suggesting they might shelter the screen even more. They also offer three levels of backlighting, or no lighting at all.

We were sent the Charcoal Signature Type Cover to accompany the Surface Pro 7. Other colour options



include Poppy Red and Ice Blue. All three are coated in the soft, yet durable Alcantara fabric, which seems a bit less furry than in generations past.

As you might expect, the Type Cover includes a Microsoft Precision Touchpad, which easily processes taps and other gestures. It's clickable over its entire surface, though it requires a bit more effort near the top. At this point, Microsoft has done a surprisingly good job of nailing the inking experience. You'll have to buy a Surface Pen, sure. But setup is a breeze, with a quick walkthrough via the Surface app. A click of the rubber eraser and the Surface Pro 7 launches the Whiteboard app – not my first choice for drawing, but



a real pleasure to use nevertheless. Digital ink flows smoothly as the Pen glides over the display, and the pen connects magnetically to the side of the tablet.

Note that the Camera app turns on the user-facing camera by default – perhaps assuming you live within Skype. The rear-facing camera offers normal and panorama photography, plus document-scanning and whiteboarding options. Virtually everything on the Surface Pro 7 is about productivity.

Ports: USB-C, but no Thunderbolt yet

If you've owned a previous Surface, you'll be happy to know that the Surface Connector remains the same,



allowing you to use an old Surface charger with the new model. The same goes for the Surface Dock, which Microsoft has never updated.

What is new about the Surface Pro 7 is the addition of the USB-C port – and the removal of mini-DisplayPort. In all, this is a net positive for the Surface Pro range, given the wide and varied range of USB-C hubs to compensate for a single, dedicated port. Tablets like Lenovo's ThinkPad X1 tablet have previously offered more flexible port options, and it's nice to see Microsoft's prosumer tablet line catch up. The Surface Pro X offers a pair of USB-C ports, however, compared to the Surface Pro 7's single port.



Some rivals go beyond this to offer a Thunderbolt-enabled USB-C port, which allows more bandwidth for connecting to secondary monitors and the like. In the Surface Pro 7's case, its USB-C port (specifically USB 3.1 Gen 2, at 10GB/s, using DisplayPort 1.4) will accommodate a pair of external 4K displays at 60Hz. The Surface Pro X's capabilities slightly outshine the Surface Pro 7's: it can connect up to two 4,096x2,304 displays using its pair of USB-C ports.

The Surface Pro 7's USB-C port can also be used to charge the tablet, which offers additional flexibility. Like the Surface Laptop 3, the included charger offers quick-charge capabilities, too.



We've beat this drum before, but we'll sound it again: If the Surface Pro series had Thunderbolt as well as the Surface Connector, you'd have two high-speed I/O interfaces. You can still connect to the Surface Dock. But there seems to be a missed opportunity here.

Don't forget about the microSD card slot under the kickstand, as in previous models. Sure, Microsoft would like you to upload your smartphone photos directly to the cloud. But as long as point-and-shoot cameras exist, moving the microSD card from the camera to the phone remains an easy way to upload your photos. Most USB-C hubs already include a microSD slot, however.

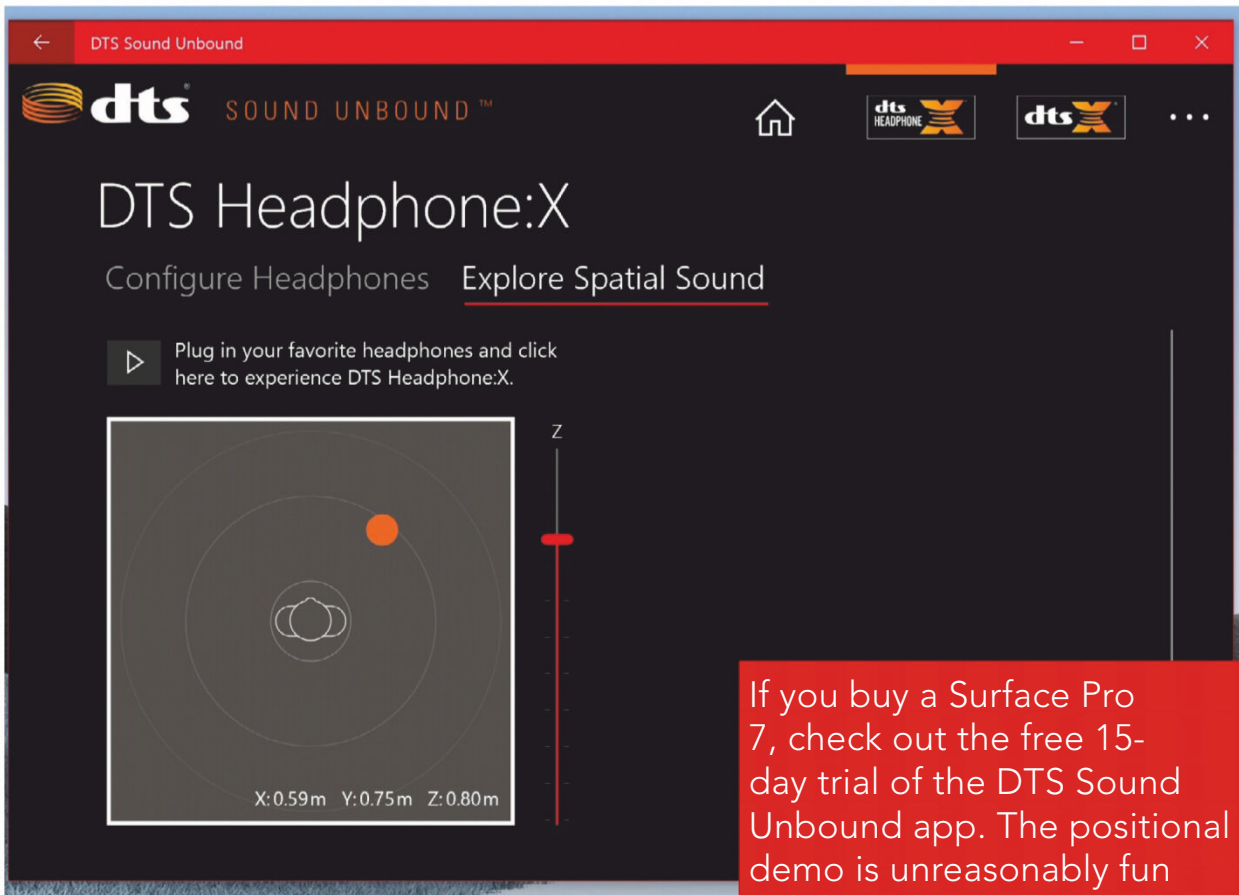
So far, Microsoft hasn't announced an SP7 with an integrated or external SIM. For that, you'll want the Surface Pro X.

Unexpectedly nice audio

Microsoft has usually designed its tablets with audio in mind. Microsoft's Surface Pro 7 offers a wide, balanced range of highs and lows, though you'll still miss some of the deeper bass notes.

The Surface Pro 7 includes Dolby Audio within the Realtek Audio Console app, and the sound enhancement is on by default. Though the app doesn't provide any equalizer functions, the default configuration sounds suitably balanced for you to enjoy audio over the tablet's speakers – still a rare luxury in today's laptops.

DTS Sound Unbound is a surprise, a paid app that's bundled with the tablet. It asks you to pay to unlock surround sound from both your speakers and



headphones. Its positional audio was, however, the best I can recall since Aureal Semiconductor's HRTF positional audio demo two decades ago.

Performance: top of the tablets

It would be nice to wave away some of the Surface Pro 7's performance requirements, in an argument that a simple tablet deserves some concessions. That argument holds more water with the Surface Go (£379 from fave.co/37pVEZA). Because there's a strong chance that our £1,449 Surface Pro 7 will replace a notebook PC as a primary device, however, we can't use the same criteria.

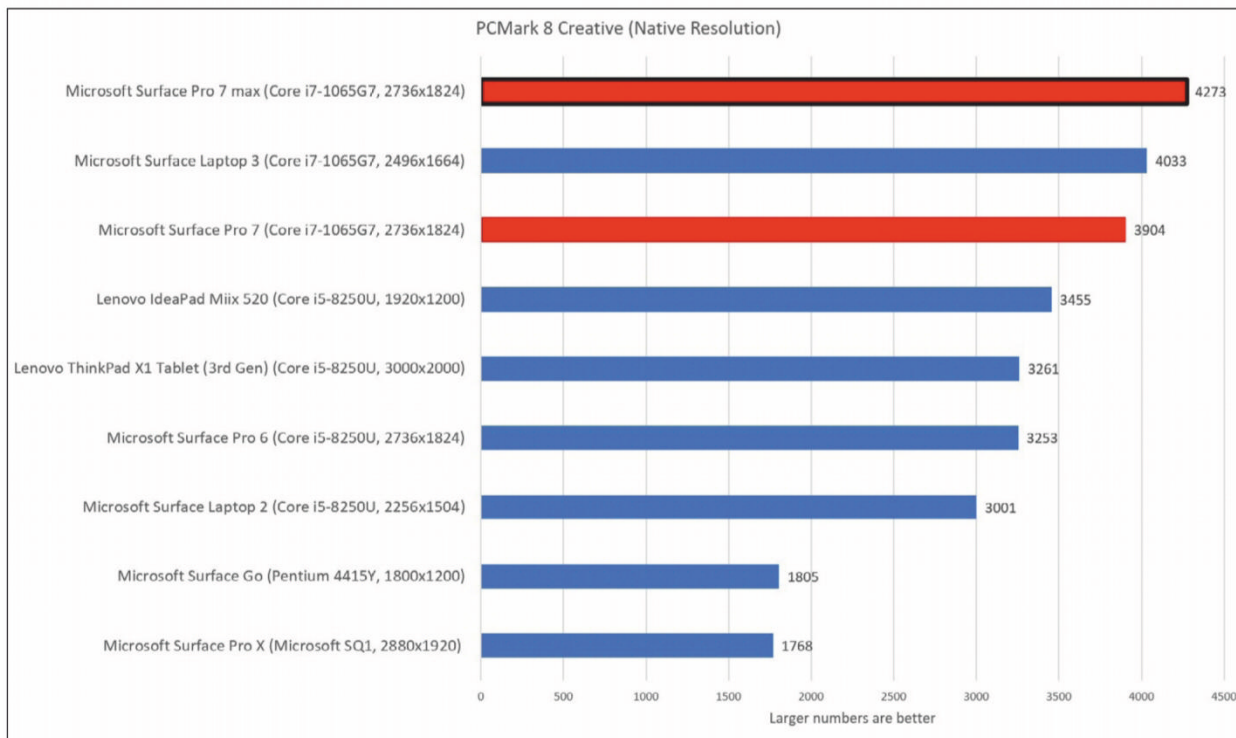
We also can't directly compare the Surface Pro 7 to Microsoft's recent Surface Pro X in all but a small handful of benchmarks. In large part, that's because the two devices use different microprocessors: the Surface Pro 7 uses Intel's mobile Ice Lake chip, while the Surface Pro X uses a custom chip based on Qualcomm's Snapdragon architecture. The latter can't run most benchmarks that we use to test Windows laptops and desktops, but you'll see it in a few where they intersect.

Given the somewhat limited comparison set, we've also included the Ice-Lake-based Surface Laptop 3 for Business. This laptop and its tablet cousin actually bear a close resemblance on paper – they share the same exact processor and GPU, clocked identically. As you'll see from the CPU-specific Cinebench test below, the CPU performance of both the Surface Pro 7 and the Surface Laptop 3 are close.

Our daily experiences with the Surface Pro 7 – everyday Office use, web browsing and the like – were more than acceptable. The Surface Pro 7 also offers 'instant on' capabilities, waking almost instantly with a combination of the Windows Hello-enabled camera and a fast internal SSD.

Our first test is the older PCMark Creative benchmark, used in part because we could pull results from a couple years' worth of tablets. It measures light gaming, photo and video editing, and web browsing. Not surprisingly, the Surface Pro 7 excels.

Note that the default behaviour for the Surface Pro 7, like the Surface Laptop 3, is to prolong battery life, sometimes at the expense of performance. That's a perfectly acceptable choice, but we also tested while

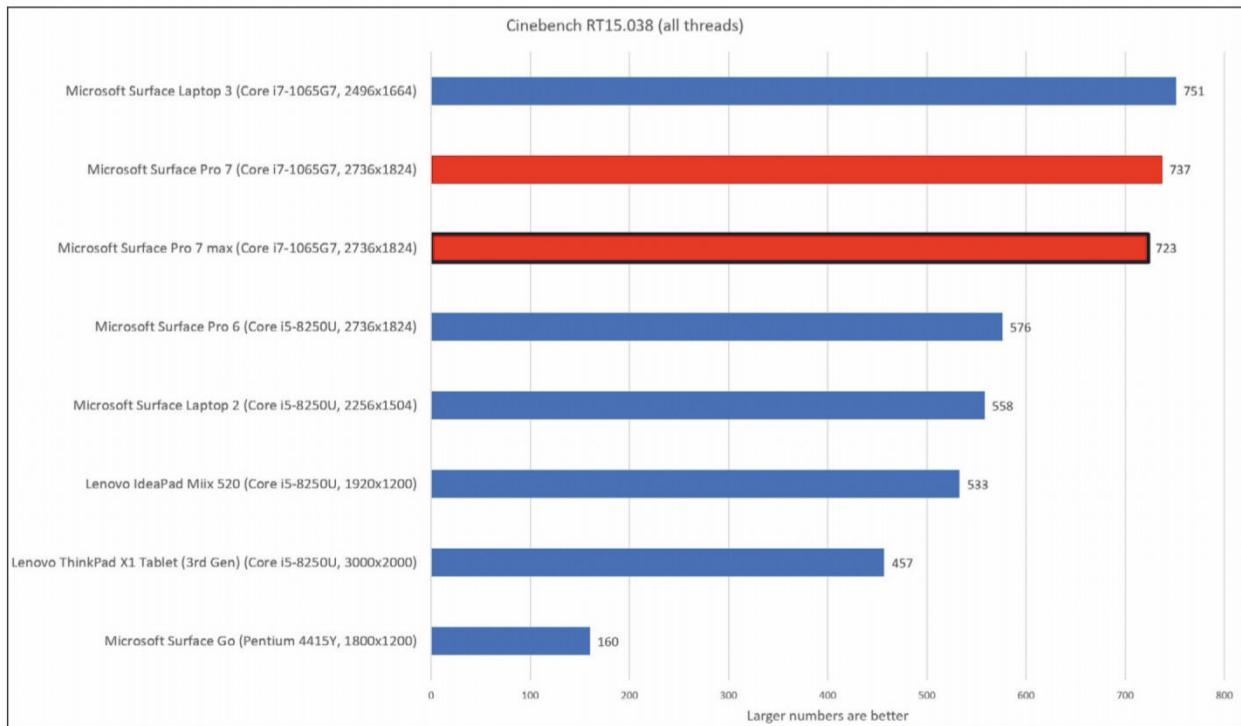


Especially when you dial up the performance, Microsoft's Surface Pro 7 is the fastest tablet around for everyday use, as measured by PCMark 8

maximizing the performance (noted with the black outline). In some tests, that made a difference. In others, it didn't.

In terms of pure CPU workloads, we use the Cinebench benchmark, which renders a CGI scene using the full power of the CPU. The Core i7-1065G7 is a 4-core, 8-thread processor, just like the older chips that power the Lenovo IdeaPad Miix and ThinkPad X1 Tablets. But it's fabricated at 10nm, giving it a performance advantage over the older 14nm chips.

Our other CPU benchmark is a stress test, a prolonged transcoding exercise using the open-source Handbrake app. It tests both the CPU's stamina and the device's ability to stay cool during a rigorous workload.

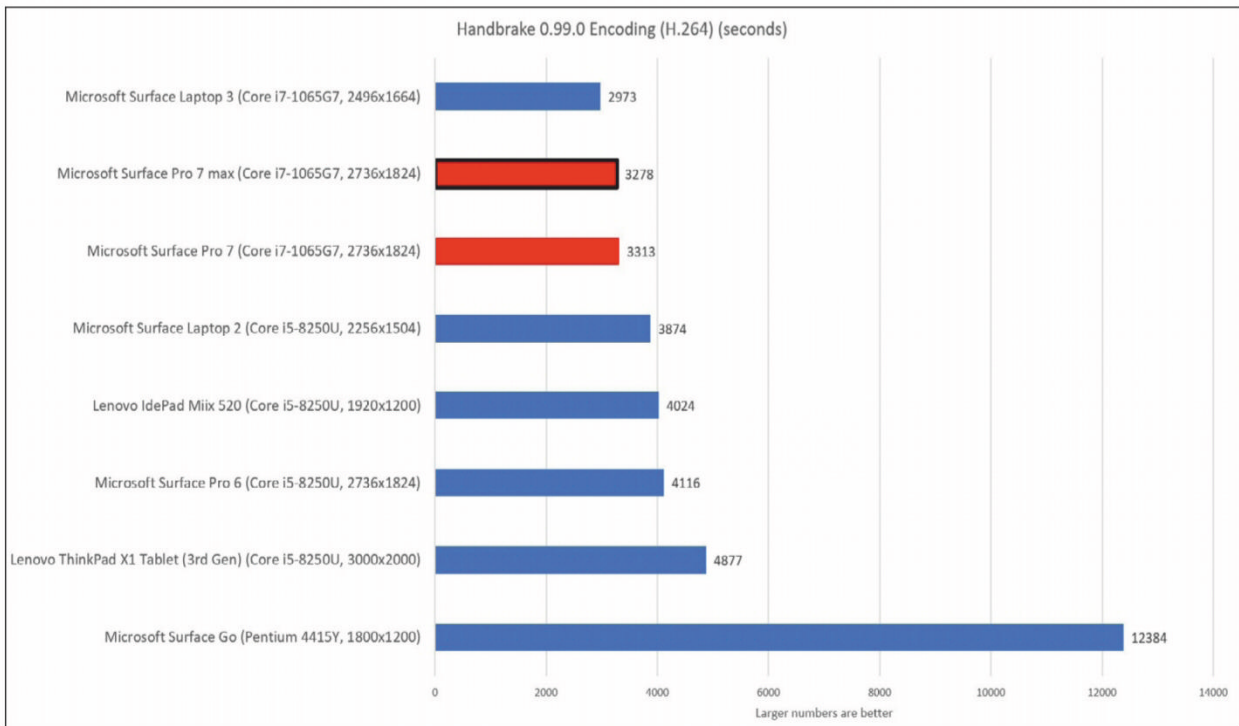


Two identical processors, two nearly identical scores

The Surface Pro 7 delivers decent performance here, but we suspect some slight throttling may be at work.

When it comes to graphics benchmarks, the differences become clear. We saw some rather significant differences in GPU frame rate in our 3DMark Sky Diver test, which developer UL touts as a benchmark for gaming machines.

Though the Surface Laptop 3 for Business and the Surface Pro 7 share a common CPU and GPU platform, the differences in this benchmark are stark. Why? Using Intel's Power Gadget widget, we traced the GPU power and frequency as it ran the benchmark. The Surface Pro 7 seems to throttle the GPU pretty hard in this particular test. Though the SP7's GPU occasionally spikes to a peak speed of 3.7GHz, it tends to run at prolonged

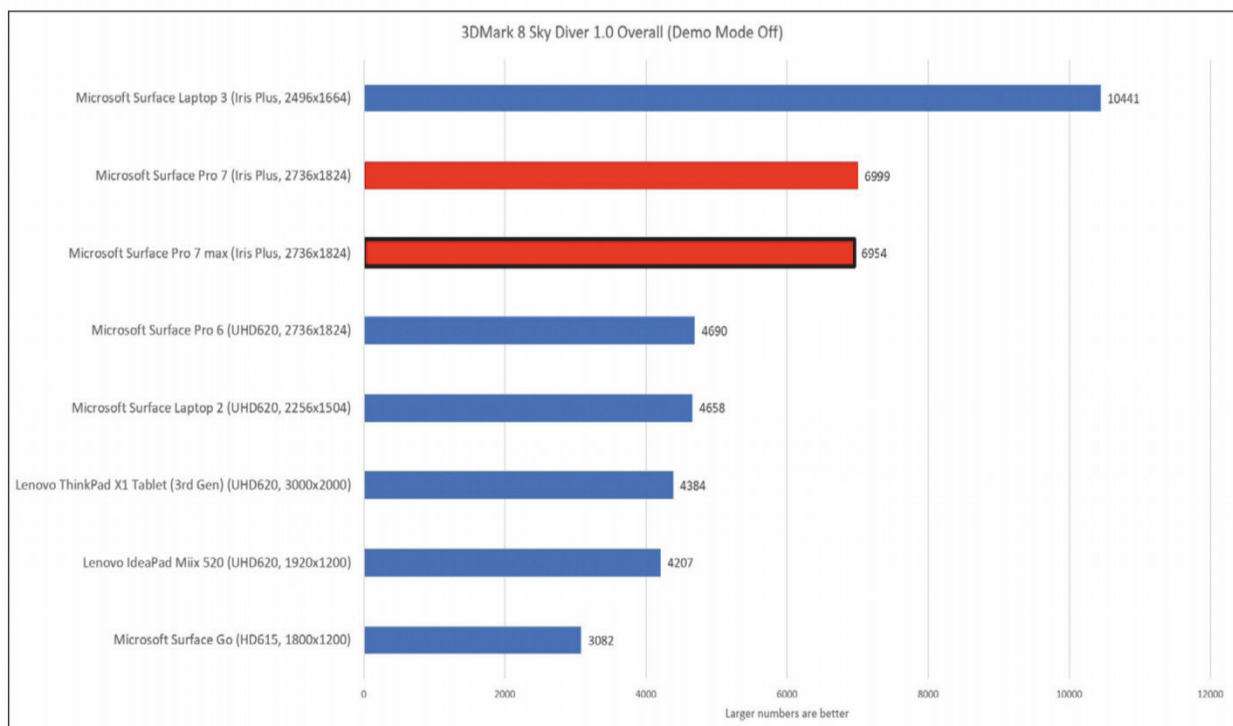


The chart is distorted by the agonizingly slow performance of the Microsoft Surface Go, but the Surface Pro 7 is still superior. Better cooling on the Surface Laptop 3 helps its prevail

periods at 267MHz. The Surface Laptop 3's typical speed is 283MHz, and with much longer prolonged 'spikes' of 3.35GHz to 3.75GHz. This translates to better prolonged graphics performance.

The gist of this result is that quasi-modern games like Grand Theft Auto V will play, though you'll have to dial down the resolution down to 720p or so and turn off most of the advanced graphics options off. The Iris Plus graphics integrated into Intel's Core i7-1065G7 provides decent GPU performance, almost (but not quite) to the point of a low-end discrete GPU.

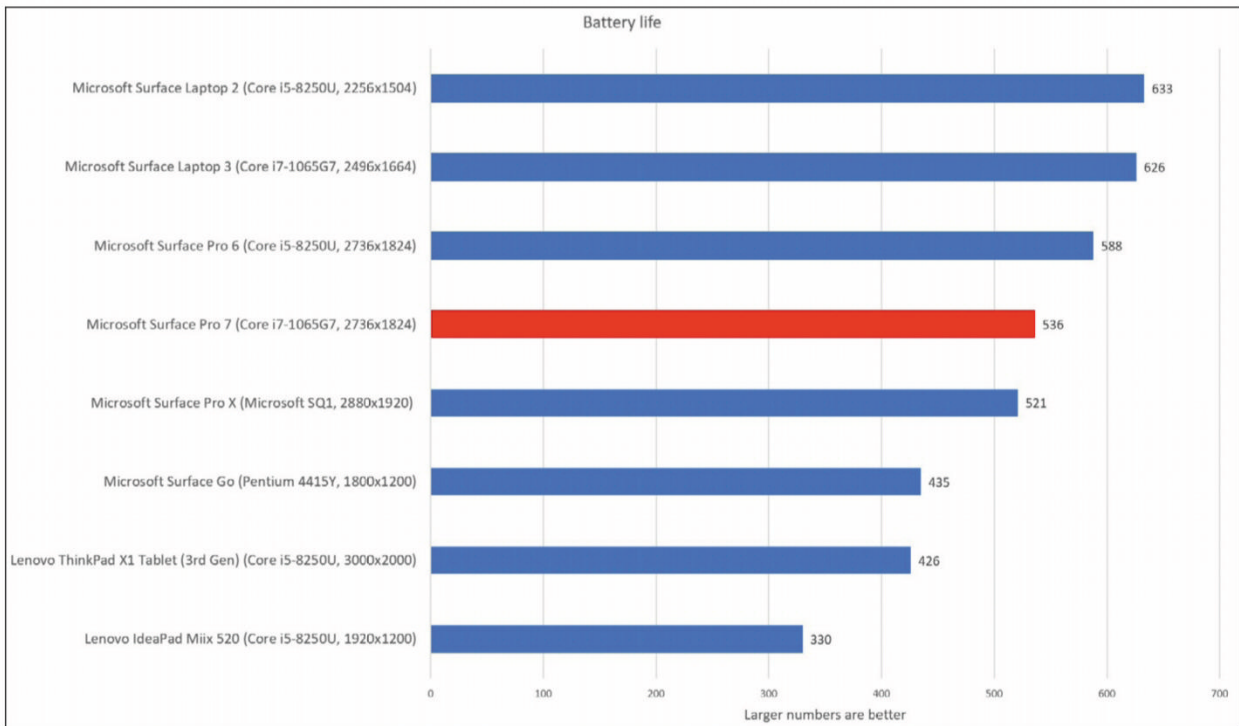
As noted above, we definitely see some throttling going on within the Ice Lake GPU, resulting in a



The Sky Diver benchmark shows sharp differences between the Surface Laptop 3 and the Surface Pro 7, but there is also a pronounced performance improvement over the older tablets

sharp difference between the Surface Laptop 3 and the Surface Pro 7. Stay focused on the real message, though: The Surface Pro 7 outperforms all other tablets we've tested by a substantial amount.

Finally, we look at battery life. We charge to full and then pull the plug as we loop a 4K video, with volume set to about 50 percent, until the battery dies. At a design capacity of 43.2Wh, it's a tad smaller than the Surface Pro 6's 45Wh battery. (Full charge capacity on the SP7 was 46.4Wh, indicating some variation in the manufacturing.) The older Core i5-8250U can run as low as 10 watts, while the i7-1065G7 runs as low as 12 watts. Did that make



The Surface Pro 7 delivers about what we'd expect of a prosumer-level tablet's battery: about 9 hours from a 43Wh supply

a difference? Perhaps. In any event, battery life just shy of nine hours is satisfactory.

Verdict

It's no surprise that the Microsoft Surface Pro 7 comes out on top within its limited field of competitors, especially because it's the first Windows tablet we've seen with the Intel Ice Lake platform.

The Surface Pro design retains some advantages. For many, the inclusion of a USB-C and an older USB Type-A port represents an ideal compromise, even if we'd have preferred Thunderbolt. The kickstand is overlooked as an absolute necessity for desk work. Even the chunky bezels make the tablet easier to tote

from room to room while playing Spotify or Netflix. Surface pioneered the Windows tablet market and has delivered a quality experience generation after generation in the years since. Nothing has changed in that regard. Right now, the Surface Pro 7 is the best Windows tablet you can buy. **Mark Hachman**

Specifications

- 12.3in (2,736x1,824; 267ppi) PixelSense Display
- Windows 10 Home
- Quad-core 10th Gen Intel Core i7-1065G7 processor
- Iris Plus 940 GPU
- 16GB LPDDR4x RAM
- 256GB SSD
- 1x USB Type-C
- 1x USB Type-A
- MicroSDXC reader
- Surface Connect
- 3.5mm audio jack
- Wi-Fi 6
- Bluetooth 5.0
- 5Mp front-facing camera, 8Mp rear-facing camera, w/1080p video
- 292x201x8.5mm
- 790g (not including cover)



HP Elite Dragonfly

Price: \$2,100 (£tbc) from fave.co/2HjnADV ★★★★★

The HP Elite Dragonfly is a corporate laptop made to please your manager – and isn't that the best way to get ahead in the working world? With a fingerprint-resistant finish, a beautiful cerulean magnesium body, and shoulder-friendly weight, the Elite Dragonfly is sure to earn you permission to leave 15 minutes early on Friday (thanks, boss).

Just remember, the Elite Dragonfly is designed for the boardroom, not the racetrack, so don't

expect blazing speed. What you will get is a solid configuration with some premium options; good performance, amazing battery life; and let's not forget the truly classy design. Hmmm, maybe this laptop is too good for your boss?

Incredibly light weight, insane battery life

The Elite Dragonfly's main claim to fame is its weight, which approaches 1kg when equipped with the base 38Wh battery. The trade-off is that paltry battery capacity. HP also offers a 55Wh battery for additional cost. Personally, we'd opt for the larger battery (supplied in our review unit), which increases the weight to 1.13kg.

Because your boss is likely to be butter-fingered, the Elite Dragonfly also has a better chance of hitting the

HP's Elite Dragonfly is a lightweight convertible laptop (shown with optional HP Active Tilt pen, £76 from **fave.co/31P9zY8**)



floor – and maybe surviving – as HP said it passes nine MIL-STD drop tests in drop, shock, and vibration.

What's inside still matters, though, and like most corporate premium laptops, the Elite Dragonfly has the top-end, 8th-gen Intel Core i7-8665U. You can view the full details of the Core i7-8665U on Intel's ARK database ([fave.co/2SmcynK](https://ark.intel.com/content/www/us/en/ark/products/126461/intel-core-i7-8665u-mobile-processor-12m-cache-15w-tdp.html)), but in performance you get about 200MHz higher clocks in Turbo Boost and 100MHz higher base clocks on paper. Most important is actually the support for Intel's vPro feature, which enables easier management of the laptop in a fleet environment, where 200 or 2,000 have to be accounted for.

The Core i7-8665U also supports Intel's TSX-NI and Stable Platform features. Even though the latter promises better performance for multi-threaded apps, it's supported on very few CPUs despite being introduced four generations ago with the Haswell line.

The 8th gen Core i7-8665U can technically hit higher clocks than the more common Core i7-8565U, but more importantly has vPro support switched on



Features

The Elite Dragonfly embraces its executive-laptop status, delivering a feature list that's first-class all the way. Here are the details:

CPU: 8th-gen quad-core Intel Core i7-8665U with vPro support

GPU: Integrated Intel UHD620

RAM: 16GB LPDDR3/2133 in dual-channel mode

Display: HP offers three screen options for the Dragonfly: a 4K UHD OLED screen that hits 500 nits; a blazing 850-nit Sure View Gen 3 FHD screen that lets you switch on a privacy mode so those to your right and left can't read the screen; and a power-sipping 1-watt FHD screen, which was configured in our review model.

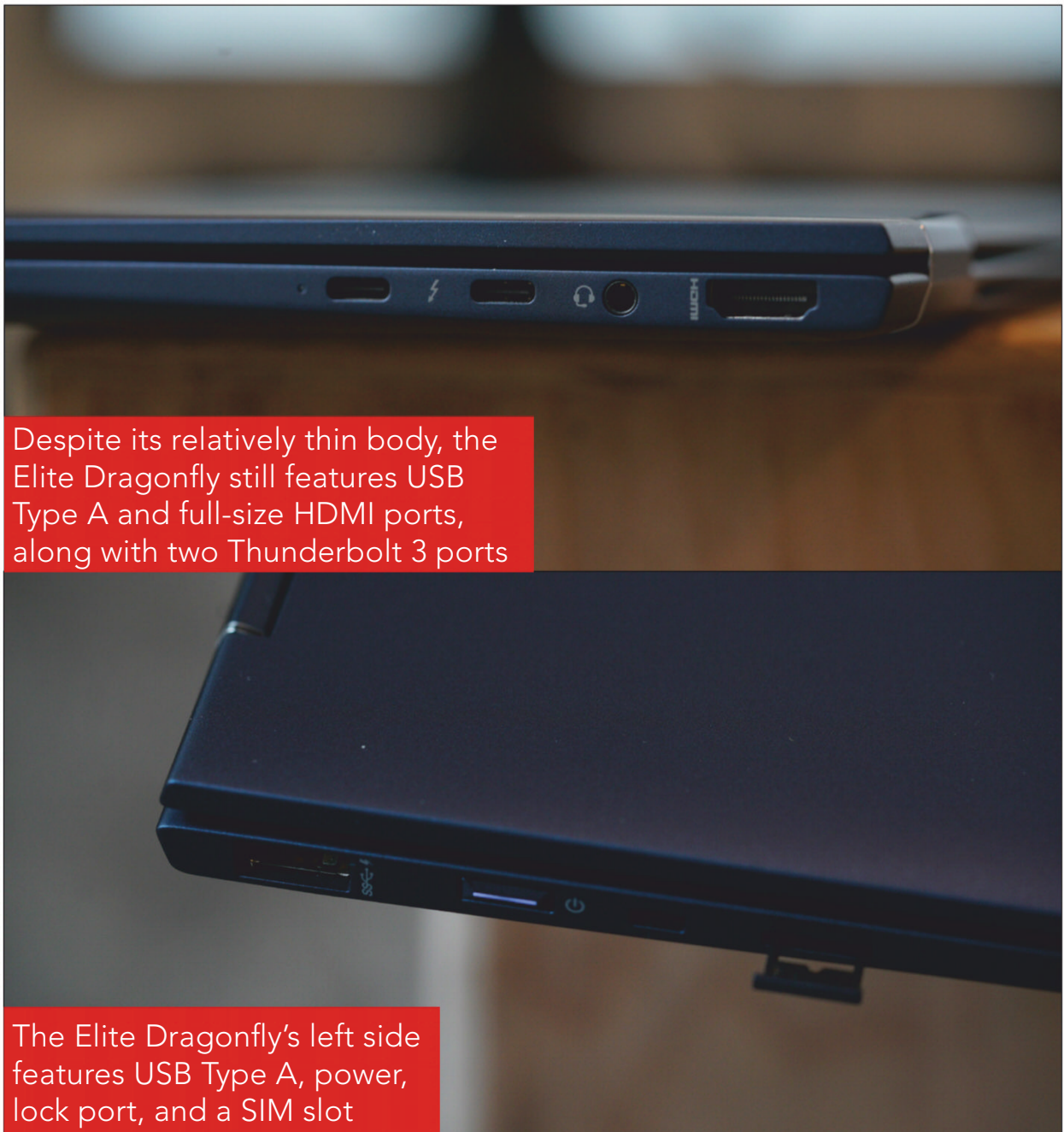
Storage: Our review sample included 512GB capacity Intel H10 Optane Memory hybrid drive. You can read our review of the H10 for the full details on the drive at fave.co/38p0x6J, but we're generally fans of it.

For a full list of specifications, go to **page 43**.

Ports

You won't have to worry about your boss barging into your cubicle to steal – borrow – another dongle. The Elite Dragonfly features two Thunderbolt 3 ports, an analogue combo jack, a wedge-style lock port, and a USB Type A port. The Elite Dragonfly also manages to pack a full HDMI port into its svelte body. We wish the Thunderbolt ports weren't both on the right side, however, as they could impede mouse usage.

Our review unit featured an Intel 4G XMM7360 modem CAT 9 modem. That's Intel's older and slower 4G chip. If you want a CAT 16 modem, HP also offers an XMM7560 upgrade. And yes, if your boss asks, just say it's a '5G modem' anyway.



Despite its relatively thin body, the Elite Dragonfly still features USB Type A and full-size HDMI ports, along with two Thunderbolt 3 ports

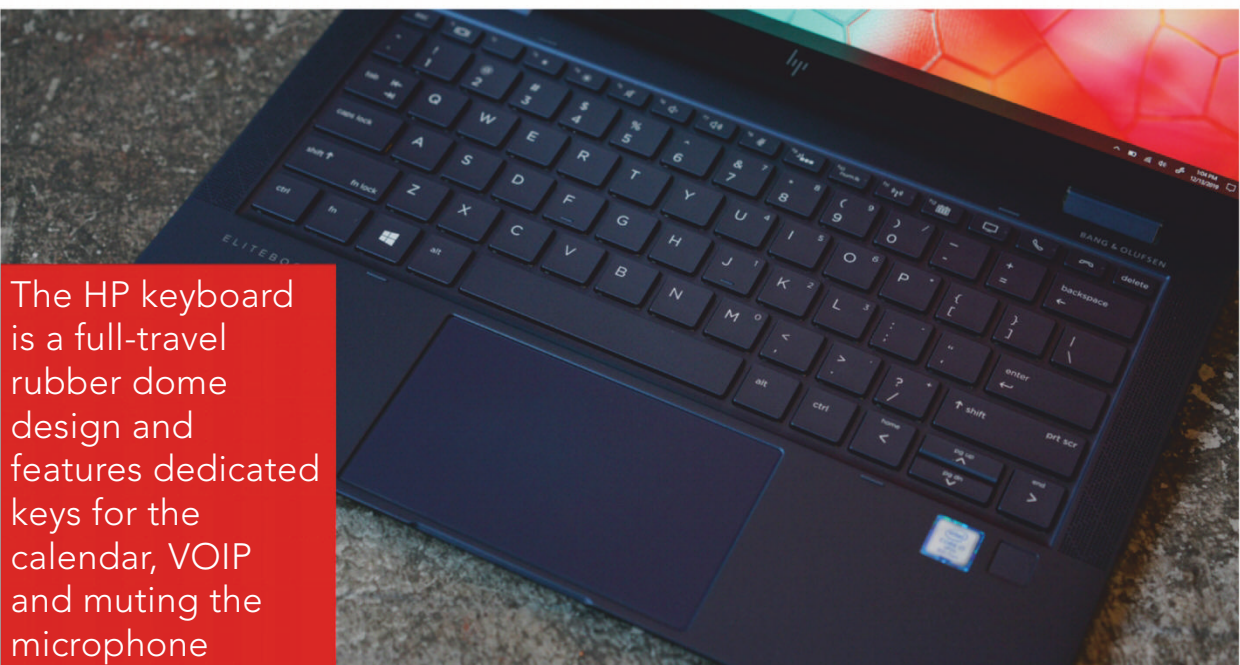
The Elite Dragonfly's left side features USB Type A, power, lock port, and a SIM slot

Keyboard and Trackpad

The input devices are top-notch, starting with a full-travel dome keyboard. There are two levels of backlighting (plus, no lighting at all). Keys are generally well placed, but HP does combine many key functions, such as pressing the function key and the right shift button to access the print screen. HP's reason for not having a dedicated print screen button is so it can have dedicated keys to access the calendar as well as several IP-based video conferencing apps.

One feature we do like is the dedicated mic mute button. It lights up, so no one can say they didn't know they weren't on mute when they bad-mouth the CEO during a videoconference.

Speaking of privacy, HP has also cleverly integrated a physical shutter over the camera. Unfortunately it also blocks the infrared camera, so you can't use the Windows Hello facial recognition when the shutter's



The HP keyboard is a full-travel rubber dome design and features dedicated keys for the calendar, VOIP and muting the microphone

active. Luckily there's a fingerprint reader as an alternate authentication method.

The Synaptics trackpad is glass and smooth. It is compliant with Microsoft's Precision touchpad requirement, which is an indication of its accuracy.

Oleophobic coating

Here's another fairly unique features on the Elite Dragonfly: an oleophobic coating to help it repel fingerprints and other greasy marks. We tested it against our typical snack fare, and found it effectively repelled most smudges from fingers that had recently handled corn chips and nacho tortilla chips. However, it was no match for the gold standard of potato chips, which caused our fingers to leave a snail-like trail on the palm rest. The oleophobic coating helps, but don't expect it to work miracles.

Security features aplenty

As a corporate laptop, the Elite Dragonfly is hardened against attacks, including those to the BIOS. HP says it can both detect scary UEFI-targeting root kits and recover from them. The Dragonfly also integrates Bromium's security technology in its Sure Click feature. It basically takes the sandboxing approach of many browsers, but enforces it in hardware.

Set up as a consumer would, the Sure Click would automatically sandbox PDF files in micro-virtual machines. By default, risky attachments are opened in micro-virtual machines using the Chromium browser.

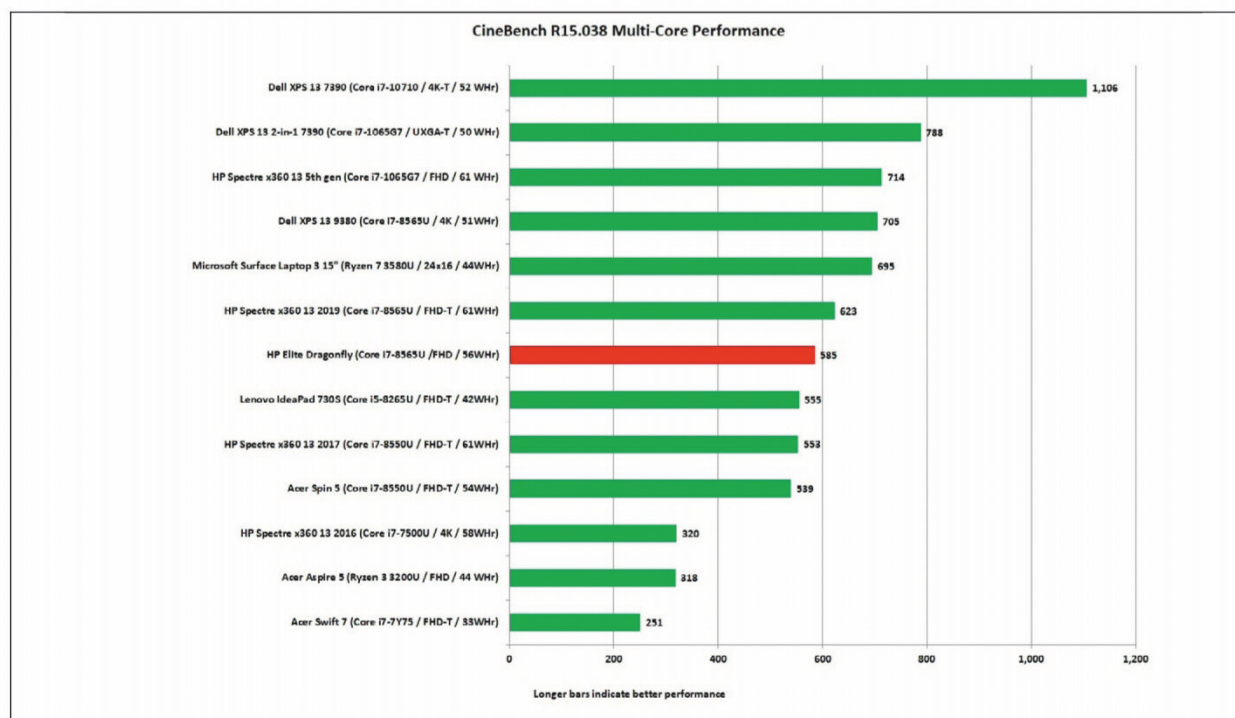
With its hardware-based security, the Elite Dragonfly lets you set up the laptop with measures ranging from

prudent to Draconian. As with all security procedures, the levels of pain are up to the administrator.

Performance

The Elite Dragonfly's performance reflects the priorities of corporate laptops, which put security and reliability over raw speed. You can see that odd dynamic right here: The 8th-gen Core i7-8665U in the Elite Dragonfly has a higher clock speed than the common consumer Core i7-8565U CPU. But one look below and you won't see it.

Maxon's 3D rendering Cinebench R15 benchmark, which measures a CPU's multi-threaded performance, shows the Elite Dragonfly under-performing against laptops with slower CPUs.

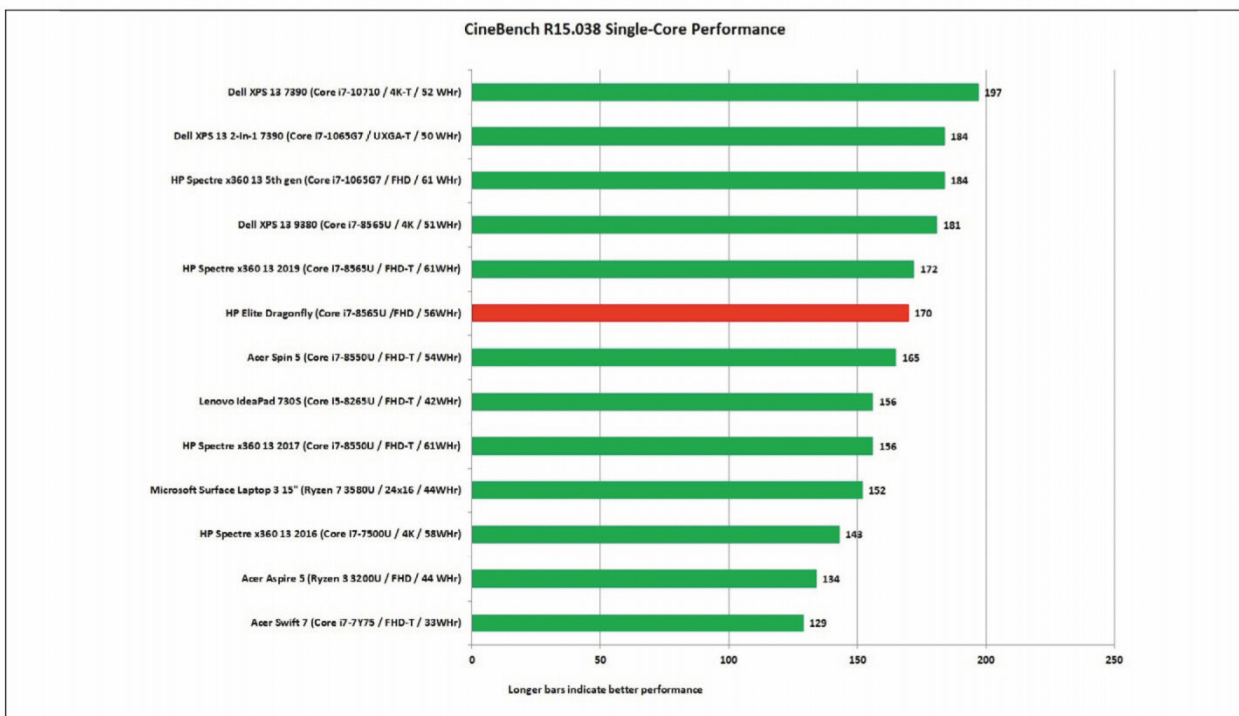


Like most business-class laptops, the Elite Dragonfly doesn't set any performance records

When we task Cinebench with using a single CPU core, the situation doesn't change much: the Dragonfly is still a little slower than most other laptops. The good news is that in single-threaded tasks – which is the bulk of what's done on small, thin laptops – it's not a big deal.

Our harshest test of a CPU uses the free Handbrake utility to encode a 30GB 1080p file. The task typically takes an hour on thin-and-light laptops, and it stresses the cooling capabilities of any laptop. We again see the Elite Dragonfly underperform other laptops.

If you're starting to wonder just why the CPU has a higher boost clock on paper, but is actually slower, the reason is that it's a business laptop. Yes, we know, you're wondering why not just buy a slower CPU? The problem is your boss still wants the best.

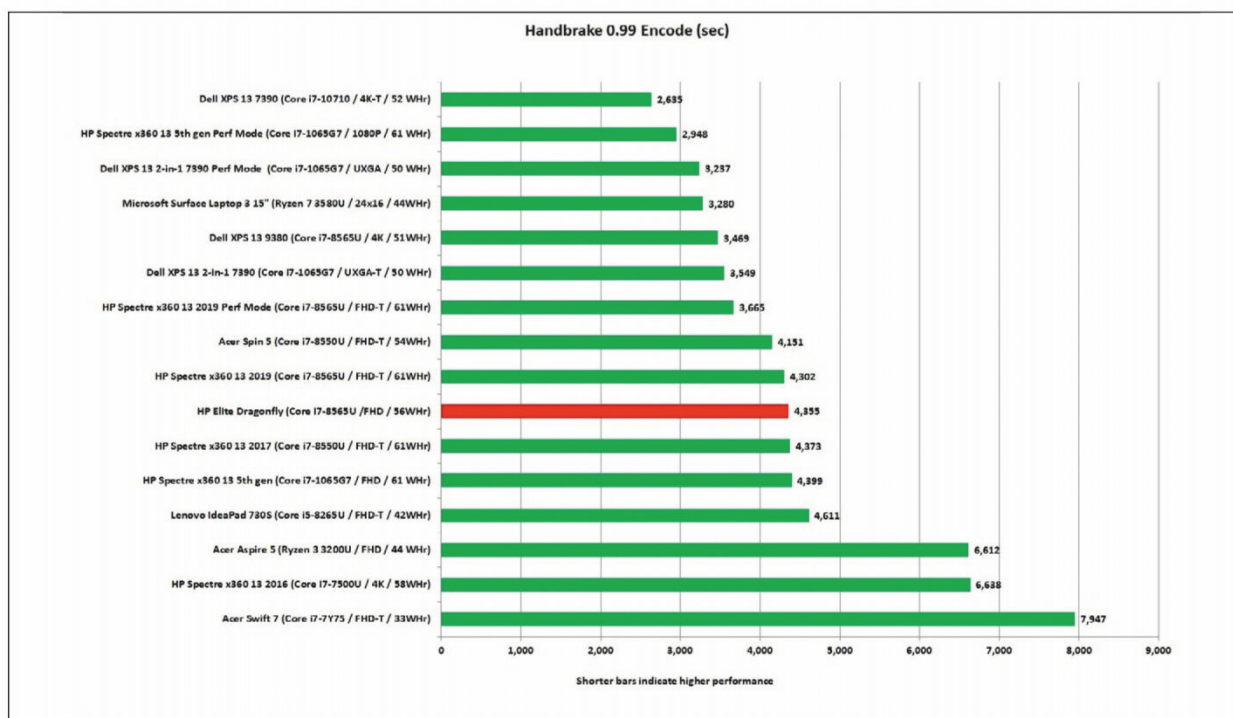


In single-threaded tasks, the Dragonfly again underperforms against other technically slower CPUs, but not by much

That's not to say the Core i7-8665U is actually slower than a consumer Core i7-8565U – it's just that to make it that fast, HP would have to add in, say, two fans instead of one, and beefier heat pipes. That adds weight, increases fan noise, and removes space for, say, more battery capacity.

The truth is, none of this matters in a corporate environment. The next test is PCMark 8 using various simulated Corporate Drone tasks of word processing, browsing, video conferencing and spreadsheeting.

As you can see, that back-of-the-pack performance of the Elite Dragonfly suddenly looks pretty good. The truth is the Elite Dragonfly is just fine for what 95 percent of Corporate Drone work requires. Just remember to tell your boss, "it's 200MHz faster".

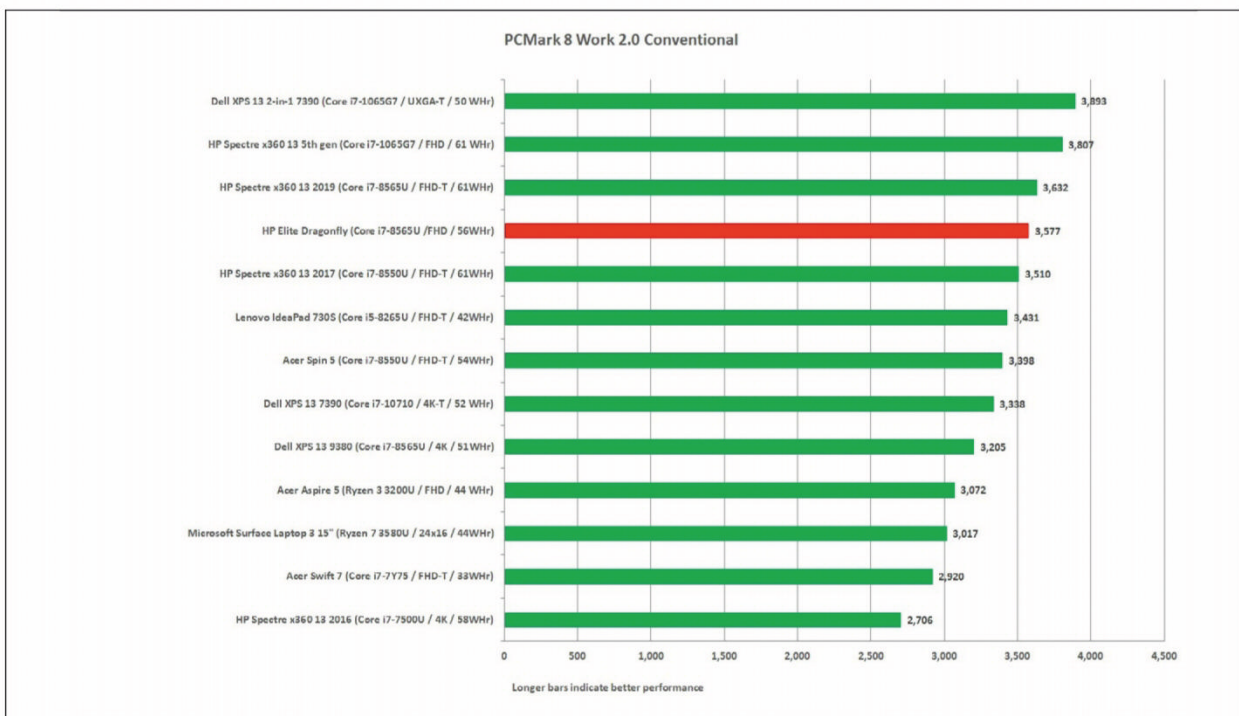


The Dragonfly also comes in well behind other technically slower CPUs in our Handbrake stress test too

Our last pure performance test uses 3DMark to measure the graphics capabilities of the Elite Dragonfly. No surprise, it's basically no better and no worse than most laptops using Intel UHD or HD graphics. We'd recommend that any gaming or graphics be kept to the bare minimum. If your boss's idea of 'gaming' means solitaire or Flash-based games, you'll be okay.

Perhaps the most important test for a laptop this portable is battery life. To test that, we loop a 4K video using Microsoft's Movies & TV app. We set the display at a relatively bright 250- to 260 nits, switch off Wi-Fi, and connect a pair of earbuds for sound.

With its '1 watt panel' and large battery, it's no surprise the Elite Dragonfly knocks it out of the park in battery life. And yes, that's about 18 hours of

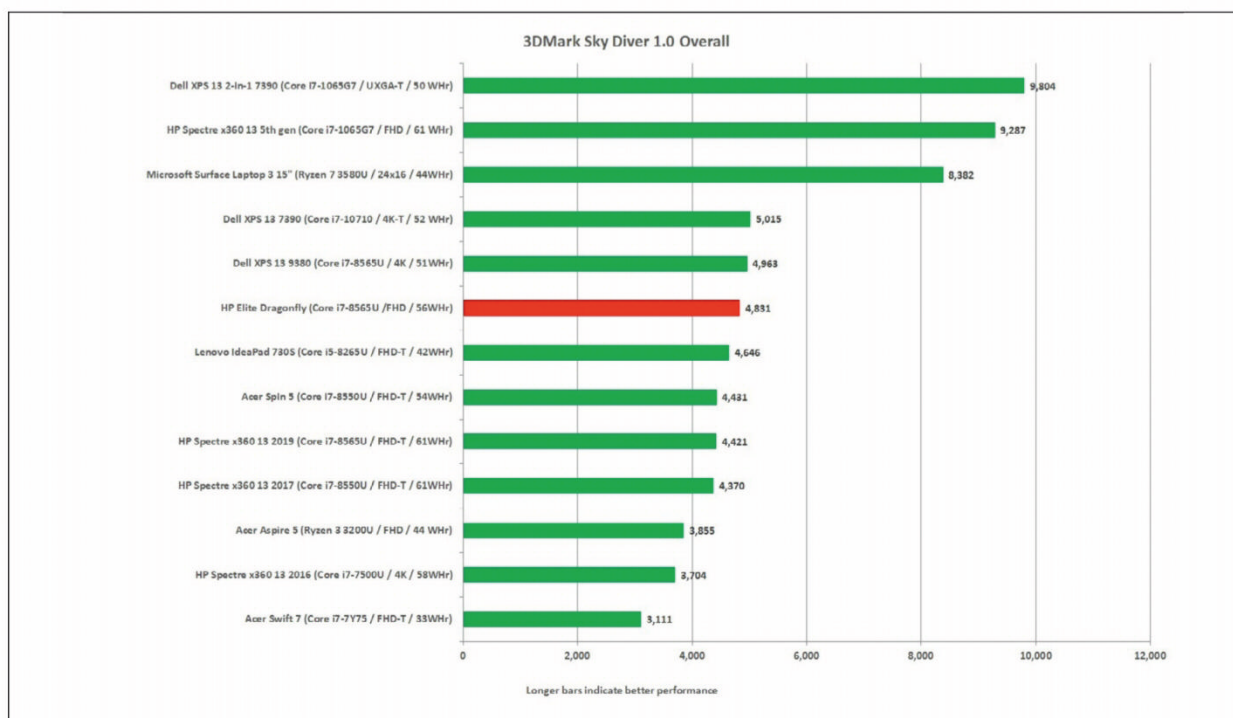


PC Mark 8 tells us it's all good for the majority of work you'd do on a thin-and-light laptop

video playback. Remember: video playback is mostly on cruise control today. Fire up Office and sit in a spreadsheet all day scrolling around, and you'll likely whack off a third of the run time. Fire up Chrome and fill it with 25 tabs, all looping and downloading continual Flash-based ads, and you can probably expect to cut the run time in half, which is still about nine hours. Fire up any application that grinds on the CPU or GPU for the whole time, and you probably shouldn't expect more than two to three hours at best.

Verdict

We'll admit, we're impressed by the HP Elite Dragonfly. It transcends our expectations for corporate laptops. Instead of boring, black, and basic, it is beautiful,

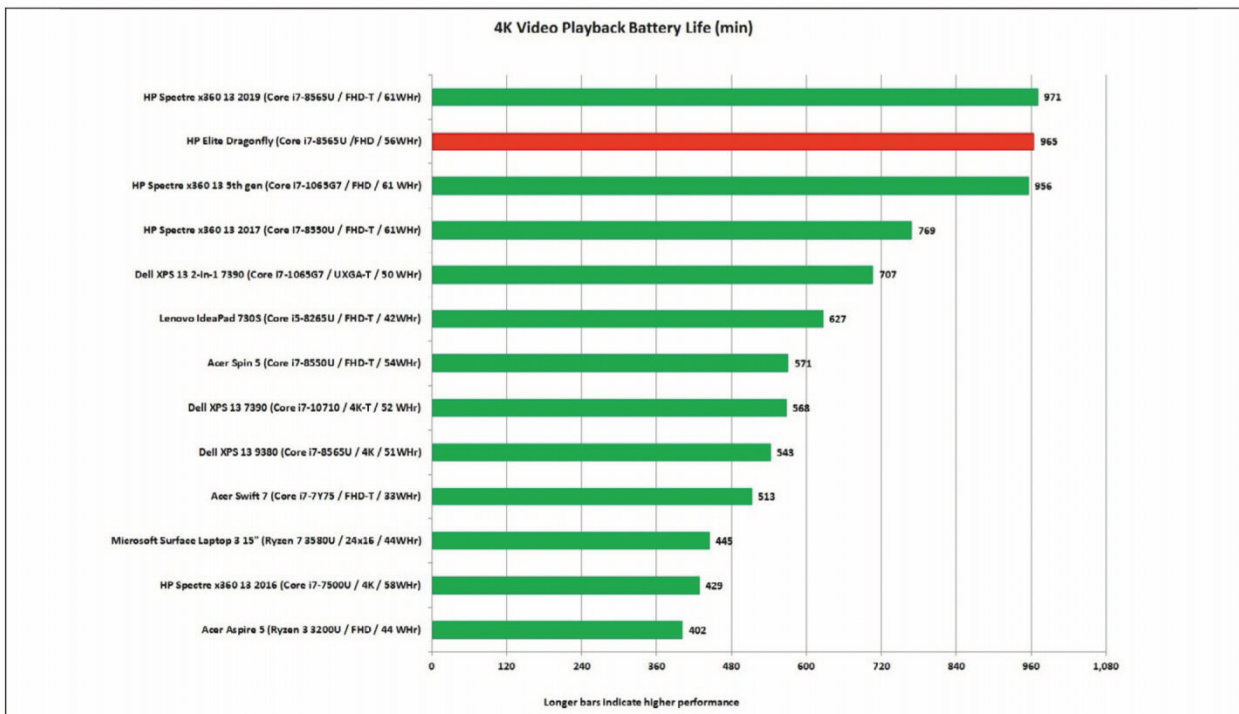


Graphics performance is in line with that of all other UHD laptops, and fine for your boss to play Flash-based games

impressively light, and surprisingly well-equipped. For consumers looking for a little more rated durability and versatility in a laptop, the Dragonfly is worth a hard look – if you can stomach the price. As a corporate laptop with manageability features such as vPro and the ‘faster’ Core i7-8665U CPU, it’ll set you back a huge amount. And that’s without the optional HP Active Tilt Pen. You could skip the pricier corporate features and still get a lot of laptop. **Gordon Mah Ung**

Specifications

- 13.3in (1,920x1,080) FHD IPS BrightView WLED-backlit display
- Windows 10 Pro (64-bit)
- 8th-gen quad-core Intel Core i7-8665U processor



The HP Elite Dragonfly's battery life doesn't disappoint in our offline video run down test

with vPro support

- Integrated Intel UHD620 GPU
- 16GB LPDDR3/2133 in dual-channel mode
- 256GB SSD
- 2x Thunderbolt (USB Type-C)
- 1x USB 3.1 Gen 1 (charging)
- 1x HDMI 1.4
- 1x External Nano SIM slot for WWAN (15)
- 3.5mm audio jack
- Wi-Fi 6
- Bluetooth 5.0
- 720p HD Camera + IR Camera
- HP Premium Collaboration Keyboard
- Bang & Olufsen, 4 Premium stereo speakers
- 304x197x16mm
- 1kg



Nubia Z20

Price: £449 (inc VAT) from fave.co/2v6pncS ★★★★★

I suspect I'll always have a soft spot for dual screen phones. It's the most absurdly over-engineered solution to a simple problem – minimizing the impact of a selfie camera on the display – but the sheer, unadulterated novelty of having two screens on one phone is hard to overstate.

The first dual screen phones admittedly weren't great, but the Nubia Z20 feels like a surprisingly mature example of a charmingly immature design, and the best case yet for slapping an extra screen on the back of a phone, thanks to a combo of attractive design, clever interfaces and a strong price point.

Screens: Two for the price of one

So yes, this phone has two displays. The main one is a 6.42in AMOLED FHD+ panel that covers the whole front of the phone, free of any notches, bezels, or pinholes – though it's worth noting that there is still some black bordering, as it's not quite edge-to-edge.

It's a bright, responsive panel with inky blacks and vivid colours. It's not the brightest I've tested – and the auto brightness setting is a little screwy, requiring manual adjustment more often than I'd like – but on the whole it's a pleasure to use. If you've never had a full-screen phone before it really is a treat to use, and it'll be hard to go back to a notch or bezel afterwards.

Then there's the back, with a separate 5.1in screen (also AMOLED, also FHD+) that sits below the camera module. This doesn't cover the whole rear of the phone, and feels a bit dinky after switching from the



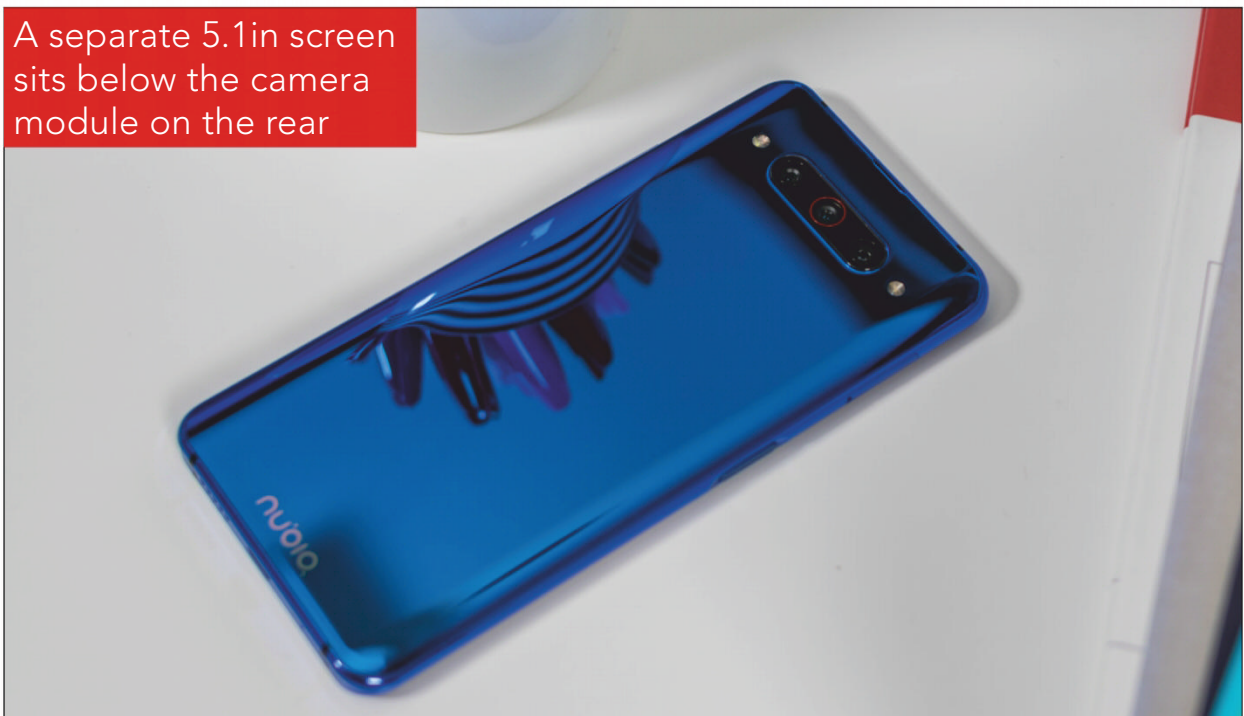
The front 6.42in AMOLED FHD+ panel that covers the whole front of the phone

front – in part thanks to the decision to preserve the front screen’s aspect ratio rather than fill out to the sides, as on the Vivo NEX Dual Display earlier this year. It’s still a very usable size, but only in brief bursts – any longer than 30 seconds and you’ll probably just want to switch back to the main display anyway.

The Z20 is available in either blue or black finishes, and as you can see one of its best tricks is that the secondary screen blends into the body – even with the blue model – making it tricky to even tell there’s a screen there if it isn’t turned on.

It does mean that my blue model has a slight tint to rear panel that takes getting used to – not helped by the decision to leave the blue light eye protection mode on by default, so I spent a few days wondering why the rear panel looked quite so yellow until I realized I could turn that off.

A separate 5.1in screen sits below the camera module on the rear



Nubia offers a few different ways to use the two different displays, so you really can figure out what works for you. You could set each power button to trigger a different screen for example, so that whichever way you pick the phone up the right-hand power button will turn on the correct display – though it's still all too easy to nudge the other fingerprint sensor and trigger the other display.

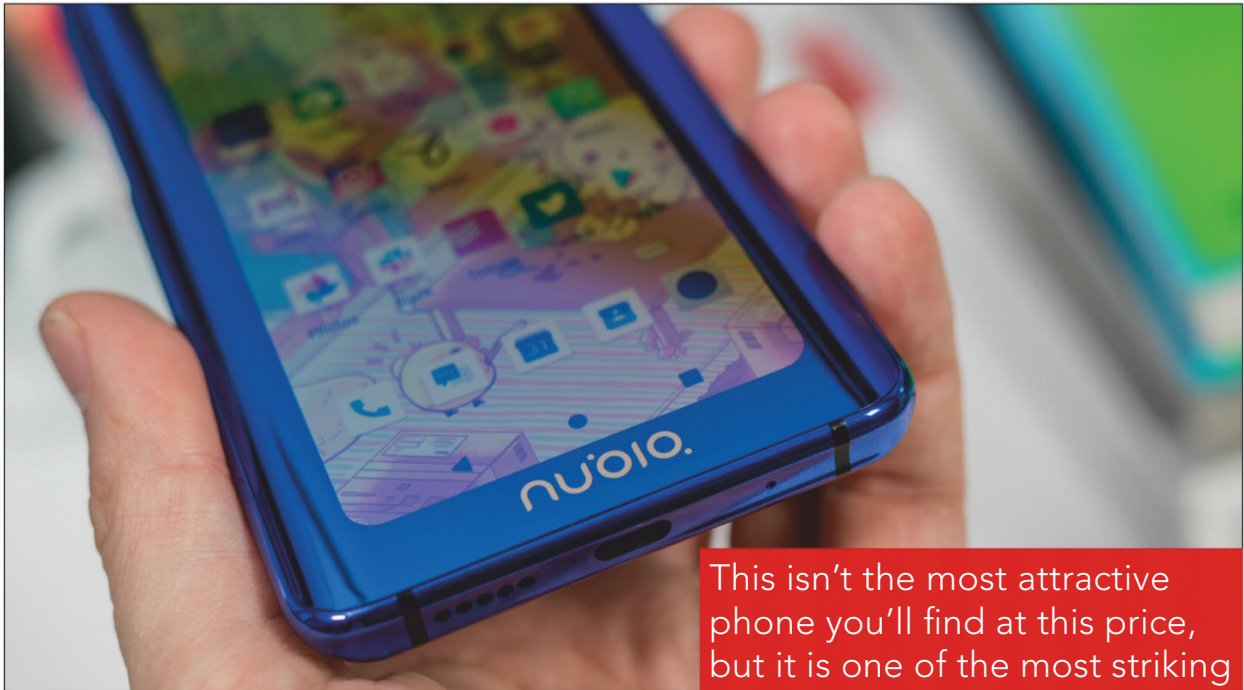
There's also the option of a floating button to swap between screens, or an automatic setting that detects the motion of you flipping the phone and switches screens as you do – though this gets a bit confused if you're using the phone at an odd angle, like while lying down.

Then you can choose whether to use the separate screens for multitasking, running different apps on each, or to simply mirror one display to the other for switching between. Throw in separate always-on display options for each panel and there's an impressive wealth of options.

Design and build: Twice as nice

To accommodate the dual displays, the Z20 also has two power buttons, each with an integrated fingerprint sensor – which could also make it accidentally ideal for the left-handed or ambidextrous among us. There's still only one volume rocker (on the right), along with a down-firing speaker and USB-C charging port on the bottom of the phone, but no headphone jack.

At 186g it's actually a lightweight phone, and feels relatively compact despite all the tech packed inside. That means it's still comfortable to use one-handed



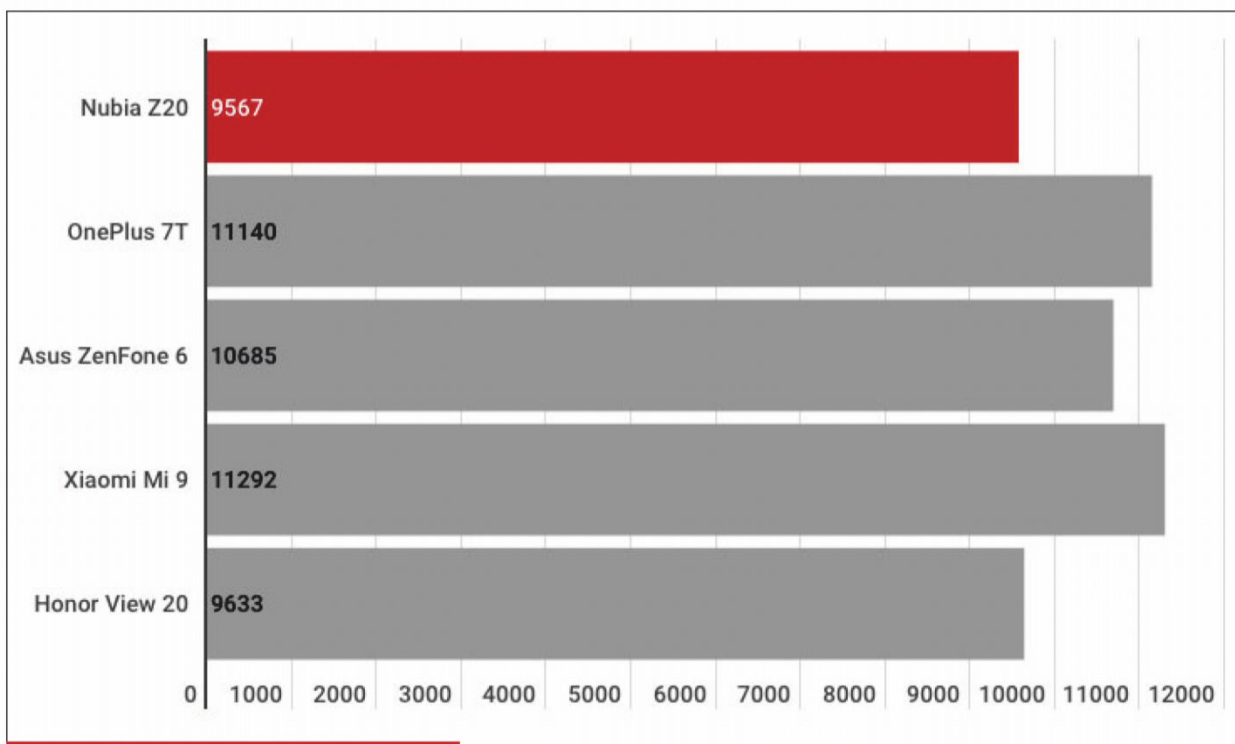
– on either side of the phone – though it's definitely not a small phone by any means.

I'm a fan of the blue finish, though it's an absolute fingerprint magnet and lacks the textured or gradient finishes popular on other coloured phones these days – understandable when there's a screen to worry about. Basically this isn't the most attractive phone you'll find at this price – but it is one of the most striking, and it makes its aesthetic work.

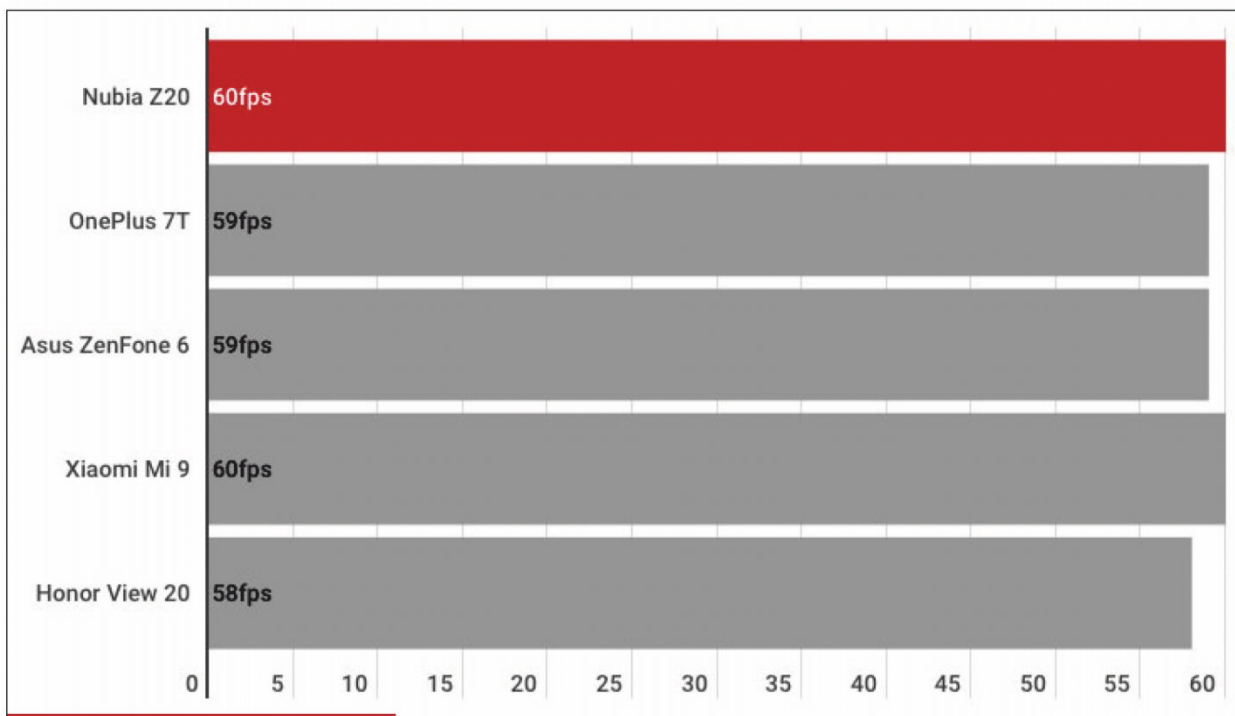
Specs and features: Double down

Arguably the most impressive thing about the Z20 is that packing in the second screen hasn't either driven the price up or the core specs down – this thing is still a powerhouse.

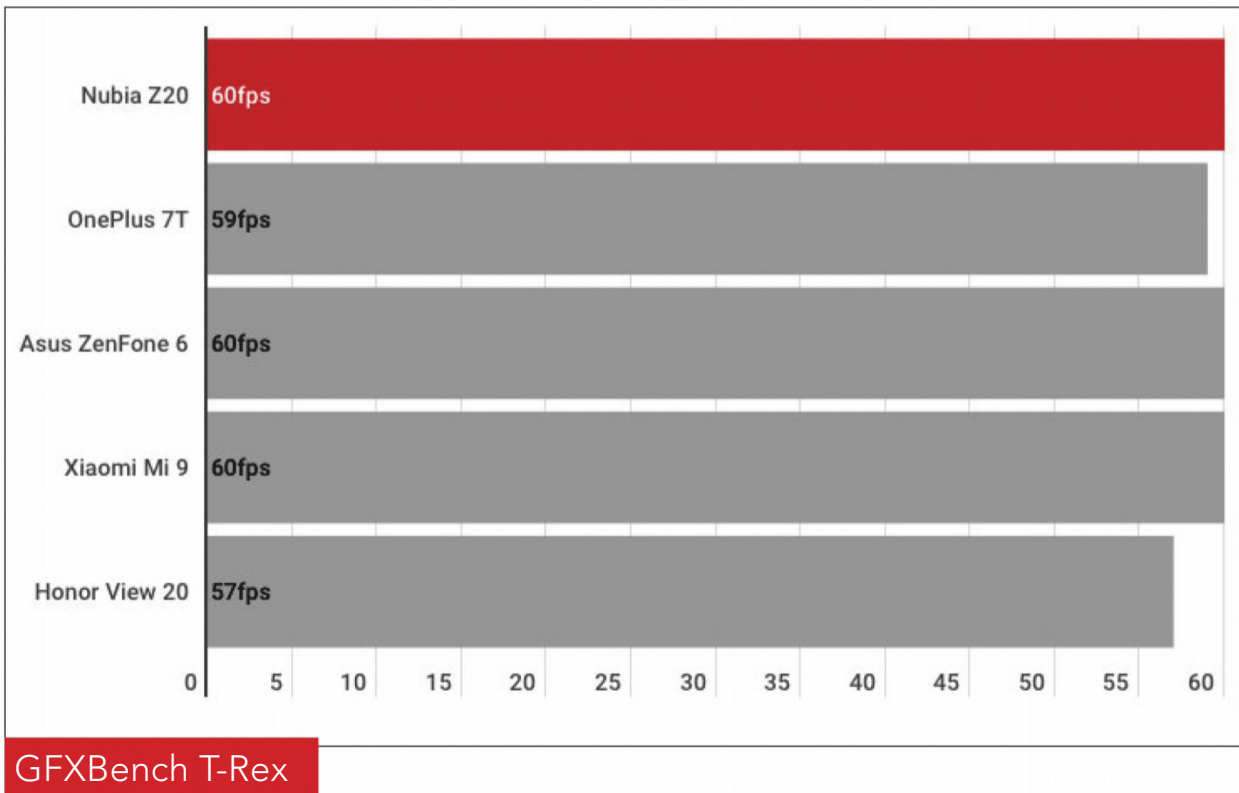
The flagship Qualcomm Snapdragon 855+ is at the heart of the phone – the fastest chip the company offers



Geekbench 4 (multi-core)



GFXBench Manhattan



right now. It's paired with 8GB of RAM and 128GB of storage, which should be more than enough for most people, though it's a slight shame that there's no option available with more storage.

In our benchmark results the Z20 lags slightly behind even slightly older mid-range handsets on CPU performance, suggesting that there's some software optimization needed to really get the most out of the hardware, but in all honesty you won't notice this in use – and its graphical benchmark results are fantastic. The phone is fast, responsive, and capable of everything from video editing to playing games.

27-watt wired fast charging tops the 4,000mAh battery up quickly, though battery life itself is variable. Essentially it depends a lot on how much you use

the second display – use an always-on display on both panels at once and the phone will drain in half a day, but with more conservative settings you can get between a day or a day and a half of use, which is pretty typical for Android right now.

The side-mounted fingerprint sensors are both quick and easy to use, and still preferable to the slightly slower in-display sensors for the most part. With no selfie camera there's no face unlock – not even on the rear display – so it's fingerprint or PIN only though.

Cameras: Less is more

An extra screen perversely means fewer camera lenses. The whole point of slapping an extra screen on the Z20's back is to avoid putting any cameras on the front. Instead, you simply use the rear cameras for every photo, turning that screen on when you want to take a selfie.

There's a benefit there, as it means getting to use the high spec rear cameras for selfies, rather than putting up with a lower resolution camera squeezed into a notch. And Nubia has leant into the Z20's camera specs – though actual performance doesn't quite live up to the promise on paper.

The main lens is 48Mp, as you'll find on a whole range of high-end phones this year – though as with most of those, it defaults to taking 12Mp photos and using pixel binning to up the quality.

HDR support does a good job of managing exposure and light levels, helped by an f/1.7 aperture, but on the standard photo mode Nubia's camera software heavily over-saturates photos and unless



you're willing to delve into the complex pro mode there's no real way to tweak those settings.

The autofocus often struggled to pick out the correct spot, especially in low light, resulting in quite a few shots that are just a little too fuzzy. There's also a passable but unremarkable night mode, and a portrait mode. Flanking the main lens are a 16Mp ultrawide and an 8Mp 3x telephoto lens. Neither offers quite the same dynamic range as the main shooter, but colours are fairly consistent between the three. Unfortunately that means they're consistently over-saturated, but that's still something.

If you flip the phone round to take a selfie, the software is smart enough to recognize which screen you're using and adjust the settings appropriately,



Low-light shot



Portrait shot



Selfie shot

taking away the night mode and telephoto options to focus on stuff you're likely to want for a selfie. One consistent annoyance is that this includes a beautification mode that is on by default and won't remember any other default – in short that means that if you don't want an AI beauty mode, you'll have to remember to turn it off for every single selfie.

The second screen offers another advantage beyond souped up selfies. It also lets you turn on both screens simultaneously while using the camera – pointless most of the time, but handy for portrait shots where you want the subject to see the shot before you take it.

As for video, the main lens can shoot in 4K at up to 60fps. It can even shoot 8K video, but since it's limited to 15fps and you probably don't own an 8K display to run it on, there's not really much point. HDR10 support is a more useful addition, as is OIS – though the stabilization is fairly basic, and may disappoint compared to some rival phones.

Software: Double trouble

Unfortunately it's not all rosy, and while Nubia has mostly done a good job of incorporating the second display into the phone, there are still software quirks that irritate. The Z20 ships with Android 9.0, but doesn't feature the gesture controls that Google began including in that Android version. That means you're stuck with the regular navigation bar at the bottom of the screen the whole time, negating some of the benefit of the full-screen display.

Translation issues abound in Nubia's custom parts of the OS – mostly devoted to the second screen

– meaning it’s very unclear what some settings will do. One option lets me ‘select lamp efficacy’, while ‘Secondary screen space’ is the name of the part of the settings menu devoted to managing multitasking across the second display.

None of these are deal-breakers, of course, and I’ve been using the phone with pre-release software, so it’s possible that some things will have been changed by the time you get your hands on the phone.

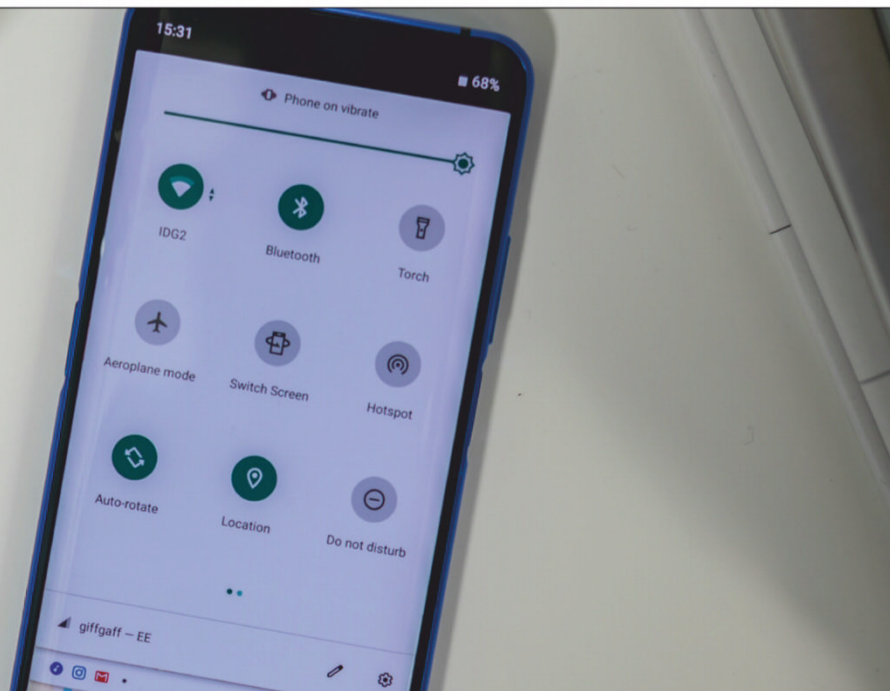
To be fair to Nubia, beyond those small flaws there’s actually a fair amount to like from the software here. The company has stuck fairly close to the stock Android experience, mostly tweaking it only to add in its own extra functionality. The phone even ships with the stock Google apps for most things, and there’s no pre-installed bloatware to deal with either.

Verdict

A dual-screen phone won’t be for everyone, but the Z20 is the closest you’re likely to get to a second display with mass-market appeal. A variety of settings and options mean you can use the second display as little or often as you like, while still enjoying all the benefits of the main camera for selfies, but it still feels a little awkward even at the best of times.

It’s just a shame that camera isn’t better, with strong hardware let down by software that’s only okay. Then again, factor in the price – and super specifications – and the Nubia Z20 delivers plenty of bang for its buck, competing surprisingly comfortably with phenomenal mid-range offerings from Xiaomi, Asus, Honor, and more.

The Z20 ships with Android 9.0, but doesn't feature the gesture controls that Google began including in that Android version



If you want a second screen, the Z20 is almost certainly the best dual-display phone on the market right now – but it's probably not quite enough to win over any new converts. **Dominic Preston**

Specifications

- 6.42in (2,340x1,080; 401ppi) AMOLED capacitive touchscreen
- Android 9.0 (Pie); Nubia UI 7
- Qualcomm SM8150 Snapdragon 855+ (7nm) processor
- Octa-core (1x 2.96GHz Kryo 485, 3x 2.42GHz Kryo 485, 4x 1.78GHz Kryo 485) CPU
- Adreno 640 GPU
- 6GB/8GB RAM
- 128GB/512GB storage
- Three rear-facing cameras: 48Mp, f/1.7, 26mm (wide),

1/2.0in, 0.8 μ m, PDAF, OIS; 8Mp, f/2.4, (telephoto), 3x optical zoom; 16Mp, f/2.2, 12mm (ultrawide), 1/3.1in, 1.0 μ m, AF

- Selfie camera: Uses main cameras
- Dual-band 802.11ac Wi-Fi
- Bluetooth 5.1, A2DP, LE
- A-GPS, GLONASS, BDS, GALILEO
- NFC
- Dual fingerprint scanner (side mounted)
- USB Type-C 1.0 reversible connector
- Non-removable 4,000mAh lithium-polymer battery
- 158.6x75.3x9mm
- 186g



Nvidia's play-anywhere GeForce Now gaming service is finally here

Game Ready, anywhere. **BRAD CHACOS** reports

Three long years after its CES 2017 reveal, and two years after its beta debuted on PCs, Nvidia's GeForce Now game-streaming service has finally launched on PCs – fave.co/2HgKxaS. The wait was worth it. GeForce Now obliterates Google Stadia's value proposition in every way, from game selection to pricing. It's available in both free and paid forms, with a 'Founders' premium tier costing just £4.99 per month.

While Google Stadia will eventually offer a 'free' tier, it's currently available only if you plunk down £119 (go

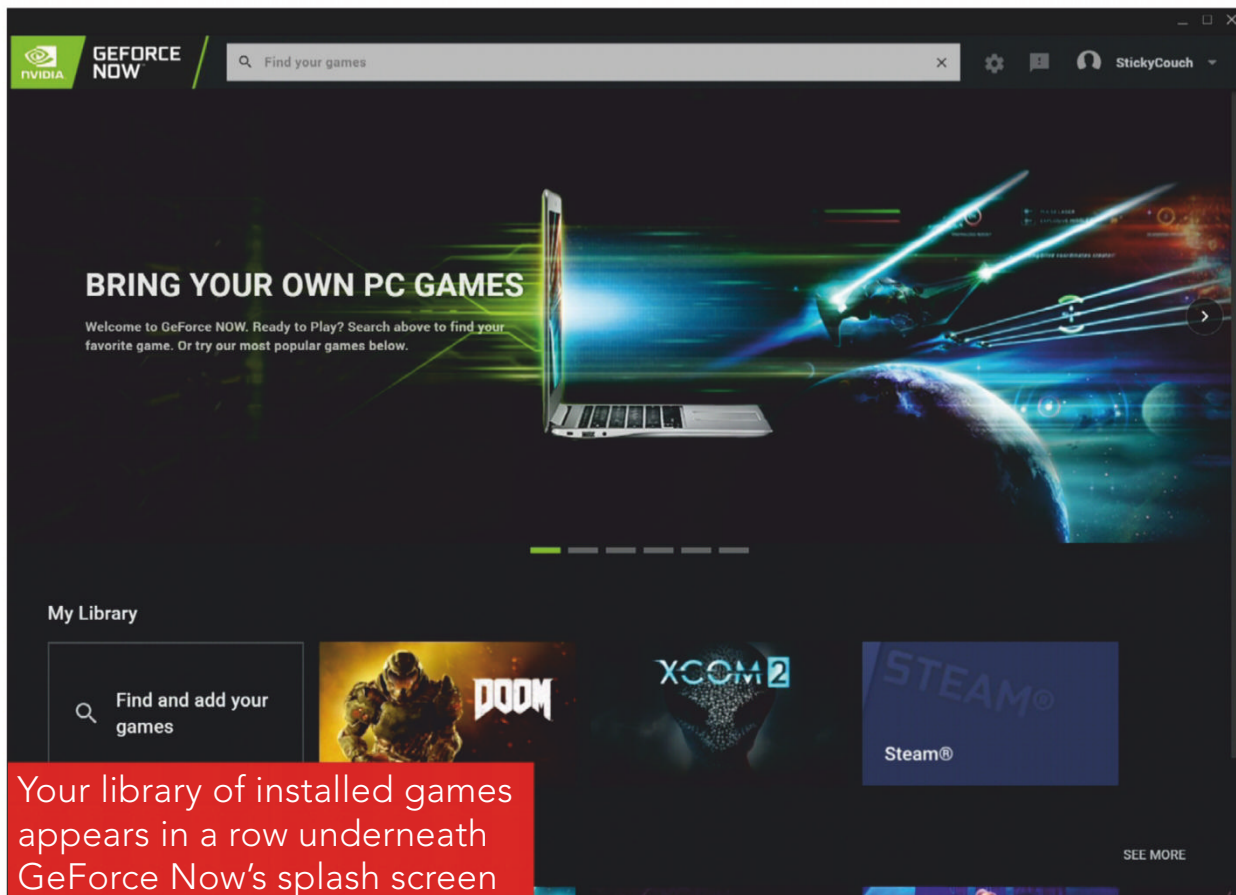
to fave.co/2uFG6Dn), then pay £8.99 per month for a Stadia Pro subscription. That Pro subscription gives you access to *Destiny 2* and a couple of other games, but you'll need to pay full price to stream any other titles in Stadia's paltry library. Even if you own a game on another service, you can't bring it over to Stadia. It's like a locked-down console in the cloud.

GeForce Now, on the other hand, is essentially a powerful gaming PC on Nvidia's servers that you can play anywhere.

How GeForce Now works

Nvidia's service doesn't sell you any games. Instead, GeForce Now taps into your existing game libraries from Steam, Uplay, the Epic Games Store, and the like, letting you play games you already own anywhere you want by signing into the service you own it on. That means the free tier can be truly free, unlike Stadia's eventual 'free' version. Nvidia's service supports numerous popular free-to-play PC games like *Fortnite*, *League of Legends*, *Counter-Strike: Global Offensive*, *Dota 2*, *Apex Legends*, *Warframe*, *Path of Exile*, and the free *Destiny 2* base game – the crown jewel of Stadia's launch line-up.

GeForce Now officially supports around 400 games, which you can find via the service's search bar. That tally includes most of the more popular titles being played today, and Nvidia says it adds four or five new games every week or so. *PUBG*, *Witcher 3*, *Skyrim*, *Borderlands 3*, *XCOM 2*, and many, many more triple-A games work with GeForce Now, as do indie gems such as *Battletech*, *Stardew Valley*, and *Disco Elysium*.



Supported games install almost instantly, appearing in your GeForce Now library bar, and launch just as quickly after that. Your save data persists between sessions with supported games, and they play nice with cloud saves when available, so you can hop between Doom on your proper gaming PC and Doom on GeForce Now on your laptop seamlessly. Nvidia keeps supported games updated with no effort on your end.

GeForce Now can also work with about 1,000 more 'single-session' games. These haven't been officially optimized for the service yet, and they aren't permanently stored on Nvidia's servers, so you'll need to download and install them every time you want

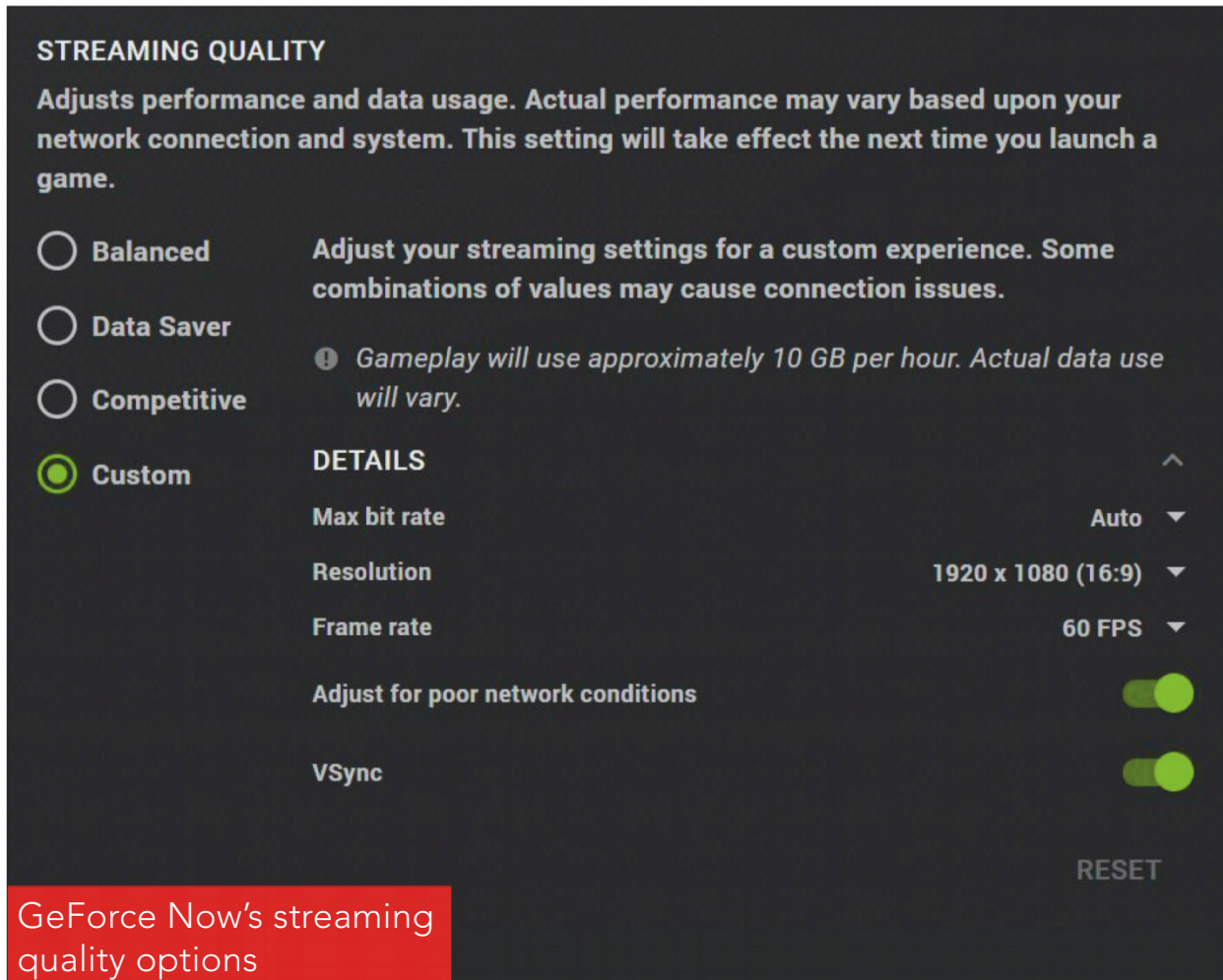
to play one. Fortunately, Nvidia's blazing-fast servers download games in the blink of an eye. Here's how Nvidia's Jordan Dodge describes single-session games: "The single session installs are games that you can play after launching Steam, but ones that we haven't had a chance to on-board yet (typically older games that you already own). The way it works is you log in to GeForce Now, and search for/click Steam as the 'game' you want to play. Once connected, you can go into your Library and can try installing those games. These installs don't persist from session-to-session (hence calling them single-session installs) but if the game supports cloud saves, you will be able to pick up where you left off during your next session."

There's bound to be some games you can't run on GeForce Now, but between the supported and single-session games, there's a huge chunk available.

How GeForce Now runs

Nvidia offers GeForce Now clients for PC, Mac, Android phones, and Android TVs (including its own excellent Nvidia Shield console). Soon, it'll launch a WebRTC-based client so you can bring the power of PC gaming to Chromebooks, too. Apple's mobile devices aren't supported, however, with Nvidia representatives simply saying "ask Apple", when I asked if iPhone or iPad support is in the works.

The games look incredible, as we noted in our impressions of the GeForce Now beta. Nvidia optimizes GeForce Now games to run well at 60 frames per second at 1080p resolution. (Unlike Stadia, there's no 4K resolution support.)



The service offers a variety of streaming quality presets. Balanced uses 10GB of data per hour and offers the best blend of image quality and responsiveness. Data saver only uses 4GB per hour, which requires some compromises, but still promises “good image quality and gameplay”. Competitive uses 6GB and focuses purely on lowering latency, sacrificing visual quality for responsiveness when it needs to. You can also custom-configure your streaming settings, adjusting resolution, bit rate, V-Sync, and whether you want to stream at 60- or 30fps.

Nvidia ensures you're running the company's latest and greatest Game Ready drivers, too.

GeForce Now played games like a champ in beta, assuming you met the modest system requirements, but will Nvidia be able to keep up once the floodgates open at the service's proper launch? That's the real question. Nvidia says that once you're up and running in a game, the quality should stay consistent, but if the servers are full, you may need to wait for a few minutes before you're able to boot into your gaming PC in the cloud. That's where GeForce Now's subscription tiers come in.

Free vs Founders subscriptions

The beta version of GeForce Now was free throughout its lifetime, and the full launch continues that tradition. GeForce Now beta testers will automatically get converted to the free plan. Free users get standard access to Nvidia's servers, and their play sessions end after an hour. You can hop back in immediately after – there is no limit to how many sessions free users get – but you can't just play games endlessly without interruption. That should help keep the queue for the service moving smoothly.

The GeForce Now 'Founders' tier lets you play for up to six straight hours, as often as you want, with priority queue access that should get you into your games immediately. GeForce Now Founders can also enable real-time ray tracing in games that support it, so if you can't afford a EVGA GeForce RTX 2060 KO (£301 from fave.co/3bxMopH), you can subscribe to Nvidia's streaming service for cheap and try out the

GeForce Now's pricing options

CHOOSE A MEMBERSHIP

FREE

£0.00 / month

- ✓ Standard Access
- ✓ 1-Hour Session Length

JOIN FREE

FOUNDERS

£4.99 / month
FOR 12 MONTHS

- ✓ Priority Access
- ✓ Extended Session Length
- ✓ RTX ON
- ✓ Free 90-Day Introductory Period*

JOIN FOUNDERS

⌚ LIMITED TIME OFFER

*One 90-day introductory period of GeForce NOW Founders Membership per user only. After the conclusion of the 90-day introductory period for GeForce NOW Founders Membership, Founders Membership subscription pricing for GeForce NOW Service will be billed monthly and is valid for up to one year, and will terminate upon any cancellation of the GeForce NOW Founders Membership. Thereafter, GeForce NOW Founders Membership pricing and plan benefits will convert to the same as a GeForce NOW Premium Membership, at the current monthly subscription price for the GeForce NOW Premium Membership service. User can cancel GeForce NOW Service at any time. Monthly subscription pricing for GeForce NOW Founders Membership and GeForce NOW Premium Membership includes VAT, where applicable. Service performance and game access time varies based on internet capabilities and/or other service delays. Android version L or above required for mobile use. Offer subject to discontinuation or change at any time. See [Terms of Use & Membership Terms](#) for additional details.

cutting-edge lighting technology for yourself. Not all ray-traced games are officially supported – Control, Battlefield V, and Shadow of the Tomb Raider are noticeable no-shows – but Metro Exodus is there with Wolfenstein Youngblood and Deliver Us to the Moon. (Metro Exodus is the one to try if you're just interested in ray tracing's eye candy.)

Nvidia's going for Stadia's jugular with pricing, too. The GeForce Now Founders edition only costs £4.99 per month for 12 months, and you'll get a free 90-day introductory period before your subscription timer kicks in. The pricing will increase sometime later, Nvidia says, so give the introductory period a try now and lock in the cost if you're interested.

Deliver Us to the Moon with ray tracing enabled



So to sum it up: Nvidia's GeForce Now is now available in full, giving you the power of a full kick-ass gaming PC on almost any Internet-connected device. It's a lot cheaper than Google Stadia, plays vastly more games than Google Stadia, runs cutting-edge ray tracing effects that Stadia doesn't, and even offers no-cost access to *Destiny 2*, the big draw of Google's pricey Stadia Pro subscription. What's not to like?

We'll see how Nvidia's servers hold up once the grubby gaming hordes descend upon them, but on paper, GeForce Now looks like the cloud gaming service we've been waiting for – the opposite of Google Stadia's stunning disappointment.



Activision Blizzard pulls its games from Nvidia's GeForce Now

Publisher pulls games. **BRAD CHACOS** reports

Nvidia and Activision Blizzard seem like close partners. Call of Duty: Modern Warfare is one of the biggest games to take advantage of the real-time ray tracing capabilities in modern GeForce graphics cards, and games like Overwatch have graced Nvidia's GeForce Now for most of the gaming-from-the-cloud service's multi-year beta. But a mere week after

GeForce Now fully launched and obliterated Google Stadia's value proposition, Activision Blizzard's games are being yanked from the service at the publisher's request, effective immediately.

No more playing Overwatch on your old laptop. No more Diablo III on your phone. No more playing the latest World of Warcraft raid boss in way better fidelity than your potato PC can normally handle. No more real-time ray tracing from the cloud in Modern Warfare.

Nvidia announced its removal with the following statement: "As we take GeForce Now to the next step in its evolution, we've worked with publishers to onboard a robust catalogue of your PC games. This means continually adding new games, and on occasion, having to remove games – similar to other digital service providers. Per their request, please be advised Activision Blizzard games will be removed from the service. While unfortunate, we hope to work together with Activision Blizzard to re-enable these games and more in the future. In addition to the hundreds of games currently supported, we have over 1,500 games that developers have asked to be on-boarded to the service. Look for weekly updates as to new games we are adding."

On the plus side, since Bungie recently broke away from Activision Blizzard, you'll still be able to play Destiny 2 on GeForce Now. The game is central to Google Stadia's £8.99 per month Pro subscription, but you can play it for no cost whatsoever on GeForce Now, as the base game's free-to-play and Nvidia offers a totally free tier. Still, Activision Blizzard's withdrawal is a major disappointment. Sure, GeForce Now still offers

vastly more games than Stadia and other cloud-based challengers, but Blizzard's Warcraft, Diablo, StarCraft, and Hearthstone are some of the most-played and most-loved franchises in PC history. Call of Duty, meanwhile, tops sales charts year-in and year-out, and Modern Warfare's removal means you won't be able to try out its ray tracing with your fancy GeForce Now Founders subscription. This hurts.

It's also a bit perplexing.

We've written at length about GeForce Now and why it rocks, and its value proposition isn't limited to gamers alone. Nvidia's service doesn't sell you games directly. Instead, it basically rents you a gaming PC in the cloud, and you sign into gaming platforms like Steam, the Epic Game Store, and (formerly) Battle.net to play games you already own. Nvidia doesn't take an extra cut. By giving you access to more powerful hardware than you might already own, GeForce Now

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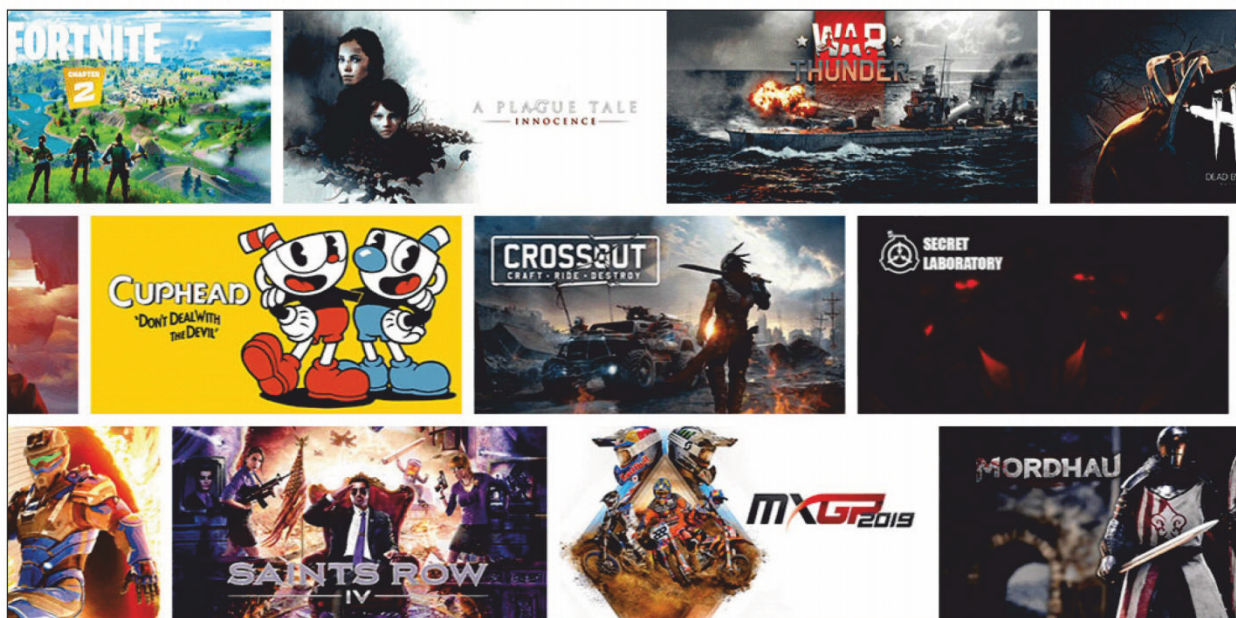
Device	User Base
MAC OS	100M Users
WIN PC	1.2B PC Gamers
TV	190M Streaming Media TVs
MOBILE	2.1B Mobile Gamers
CHROMEBOOK	25M Students

Nvidia's GeForce Now lets you play PC games across a wide variety of devices

effectively encourages you to buy more games through existing storefronts. It feels like a win-win for everybody involved. No more, alas.

Fortunately, GeForce Now remains an outstanding value proposition. While Stadia is limited to a couple dozen titles that won't work on any other platforms, Nvidia's service still supports nearly 400 games, with new titles added every week. You can also install another 1,000 or so 'single-session' games through Steam, which haven't been officially optimized for the service yet, but can still be played on-demand, with Steam cloud saves tracking your progress. Since Activision Blizzard's biggest titles live in the company's own Battle.net client, don't expect that to work as a side door here.

Fingers crossed that Activision Blizzard and other holdout publishers like EA decide to play nice with



Nvidia GeForce Now still has a huge selection of games for you to choose from

GeForce Now – and again, Nvidia’s service only lets you play games you already own and paid for on other platforms. It’s not an all-you-can-eat-buffet subscription like Netflix or Amazon Prime. Activision isn’t losing out even if the company decides to start its own rival cloud gaming service. GeForce Now is more like playing a game you already own on another PC, just one in the cloud. If you’re as disappointed about this decision as we are, your best course of action is reaching out directly to Activision Blizzard’s support and letting them know it, especially if the decision prevents you from playing games you’ve purchased.

In the meantime, if you need to level up your hardware to be able to play Activision Blizzard games you used to play over GeForce Now, be sure to check out our guide to the best graphics cards for PC gaming. Local games aren’t disappearing any time soon, as this headache proves.



Credit: Getty Images/Damir Khairov

Will virtual reality finally break out in 2020?

The hardware is cheap, the games are promising, and VR could finally be ready for the mainstream. **HAYDEN DINGMAN** reports

Maybe this will be the year virtual reality goes mainstream. If we say it enough times we'll be right eventually, yeah?

But it really does feel like 2020 might be the year. Four years into consumer virtual reality, I finally feel excited again. The hardware is great, and cheaper than

ever before. The games are promising, albeit few. And there's a sense that maybe the 'we need software to sell hardware to make developing software worthwhile' vicious cycle has finally been overcome. Maybe.

I could be wrong. I certainly hate to get excited about virtual reality's prospects in 2020, in a 'fool me twice' sort-of way. I've had my heart broken by VR before. And yet...

Quest for glory

If VR does take off in 2020, much of the credit needs to go to Oculus and its Oculus Quest (£499 from fave.co/2Hm6G7O). And listen, I love the fidelity of Valve's high-end Index headset (£919 from fave.co/2UNBlmk) driven by my desktop PC and its Nvidia GeForce RTX 2080 Ti. Who wouldn't? The image quality is fantastic, the tracking is pinpoint precise, the sound is phenomenal.

The Quest is none of these things. It looks okay. The tracking is easily broken. The sound is good enough.

It doesn't matter, because Oculus broke free from the tyranny of the tether. Suddenly VR isn't a £1,500 investment but a £400 or £500 one, period (at least when stock is available). No hidden costs, no 'Oh actually you need to upgrade your graphics card'.

Even if you have a gaming PC, Oculus Quest's flexibility is mighty appealing. I have plenty of space to use the Index with my desktop, but still find myself reaching for the Quest simply because it's less hassle. Friends of mine have expressed an interest in Oculus Quest because their PC is confined to a small room, but they have a sizable living room that would be perfect

for room-scale VR. Not to mention the fact that you can travel with Quest, or take it to a friend's house to demo.

And for an extra £80, you can have a perfectly capable PC-based VR system anyway. Oculus Link, which went into beta in November, allows you to hook the Oculus Quest up to your PC with a USB-C cable. There are cheaper cables online for £20 or so, but Oculus now sells a bespoke cable for £80 that's both longer and lays flat along the side of the headset, which is better than having some random Anker cable sticking out the side at a right angle.

It's the headset that VR needed. There's a place for Index, and its cousin the HTC Vive Pro (£690 from fave.co/37mX8Ee). Hell, there's still a place for the original Vive hardware as well. Oculus Quest is a great untethered headset though and a 'good enough'

Oculus Quest



entry-level tethered headset, and it's cheap as hell. No surprise people are buying it in droves.

Sell out with me

And people are buying it. That's, I think, the second part of this story. It's hard to get reliable sales figures, as neither Valve nor Facebook appears interested in making those numbers public.

There was a lot of encouraging news last year though. First, Mark Zuckerberg claimed during a mid-year earnings call that "We're selling [Oculus Quest units] as fast as we can make them."

Soon, even that wasn't enough. The holidays were full of reports of Quest shortages...pretty much everywhere. In fact Quest is still sold out on Amazon at time of writing, or at least only available through



resellers for an inflated price. Placing the order through Oculus's site, I'm told it will ship by 4 March.

Valve's Index is hard to get, too. The first reports of Index shortages came in late November, and by early December it was gone. Valve kept orders open for a few more weeks, with shipping estimates slipping first to February, then to March. And now? Going to the Index's Steam page, you're met with a 'Notify Me' button. Valve's effectively closed orders until it can meet the existing demand.

Even the much-maligned Oculus Rift S headset is sold out for the moment. That'd be my last pick for VR now that Quest does everything the Rift S does and more, but Oculus is still struggling to keep up.

Again, it's hard to pin actual numbers to any of these headsets. For all we know, Valve made a dozen Index kits for the holidays, sold out, and is now trying to build a dozen more. Until we see sales figures, it's hard to know otherwise.

And as a percentage of the PC audience? The numbers remain a rounding error. Looking at the Steam Hardware Survey, all the Vive and Rift and Index owners combined still make up less than 1 percent of Steam users. Hell, throw in the Windows Mixed Reality owners as well, you still only get 0.87 percent of the Steam audience owning a VR headset – or about 800,000 people, doing some back-of-the-napkin maths.

Sure, that doesn't account for Oculus Quest owners, nor for those who own a headset but don't keep it regularly hooked up. Still, VR's a long way from mainstream. There's interest in the platform though – and growing interest, if the current shortages are

anything to go by. People want VR, or at least enough people to outpace whatever Valve and Oculus planned for ahead of time.

Half-Life, and more

While Oculus deserves most of the credit on the hardware side of virtual reality, it's safe to say Valve deserves most of the credit on the software side.

It feels almost unfair to write that, because Oculus has put a lot more money into VR's software ecosystem since 2016, funded a lot of studios both internal and external, and put out a lot of good-to-great games. Lone Echo, Wilson's Heart, Stormland, Asgard's Wrath – Oculus has had a hand in a staggering percentage of the VR games worth mentioning since the Rift's consumer launch.



And they'll continue to do so in 2020. In September we finally got a look at Respawn's long-awaited partnership with Oculus, and it's *Medal of Honor: Above and Beyond*. That's a huge series to see resurrected on VR, whether or not I came away impressed by our initial demo. Ready at Dawn's *Lone Echo II* is planned for 2020 as well, and given the original is one of Oculus's (and VR's) strongest titles, I'm hoping the sequel can set the bar even higher.

If there's a forthcoming game fuelling a rush on VR headsets though, it's undoubtedly *Half-Life: Alyx*. Announced in November and set for a March release, it's the first *Half-Life* in over a decade – and it's a VR exclusive. Note that it's not an Index exclusive. Sure, Index owners get the game for free and the Index controllers will have some additional functionality, but Valve's been very clear that you can play *Half-Life: Alyx* on a Rift, Rift S, Quest, Vive, HP Reverb, or whatever the hell you have lying around.

This is Valve's big first-party VR push though. And it's the closest we've got to a system seller. I don't think that's a controversial statement – and I say that as someone who absolutely loves *Google Earth VR* and *Tilt Brush*, *Job Simulator* and *Vacation Simulator*, *Lone Echo*, *Asgard's Wrath*, *Audioshield* and *Pistol Whip* and *Beat Saber*, *Robo Recall*, *Moss*, and too many more to mention.

Point being, I've played a lot of VR games over the years, and had favourites come and go. I keep a mental shortlist of games for new owners to buy, games that are great to show off to first-timers, and so forth. I imagine every VR headset owner has a similar list.



Half-Life Alyx

But none – no matter the quality – have done so much with so little as Half-Life: Alyx. With one trailer, Valve upended the entire idea of what a ‘major’ VR title might mean. I don’t know if it will be good, or even interesting. Nor do I know whether it will outsell Beat Saber, the success of which made arcade/session-style games de rigueur for the last year or two, at the expense of more ambitious (and risky) narrative-heavy experiences.

Still, there’s a feeling I think that in Half-Life: Alyx, virtual reality finally has its showcase experience. This is Valve’s chance, and by extension everyone’s chance, to prove the platform’s usefulness. That’s a lot of weight to put on one game, but it’s almost certainly what’s fuelling recent sales, and if in the future VR is as common as WASD controls and physics engines, I expect March of 2020 will be seen as a major inflection point.

Bottom line

Or maybe Half-Life: Alyx will come and go and VR will continue on as it has, slow and steady. There's that possibility as well. I remember the heady days before the consumer launch of virtual reality, following each new development and thinking: "Wow, VR is going to change everything." Four years later, it hasn't. Not even close. Maybe VR's moment is 2020. Maybe it's 2021. Maybe it's 2031. If nothing else, I'm confident VR isn't disappearing anytime soon, even if 'slow but constant growth' isn't nearly as compelling a story as 'one day, everything changed'.



Microsoft Windows 10X: A dozen ways it's cooler than just two screens

There's a lot more under the hood than we expected. **MARK HACHMAN** reports

Before earlier this month, all we really knew about Windows 10X was that it would be some flavour of Windows 10, optimized for dual-screen devices such as Microsoft's own Surface Neo and an unknown number of third-party competitors by holiday 2020. Now we know much more, including what's under the hood.

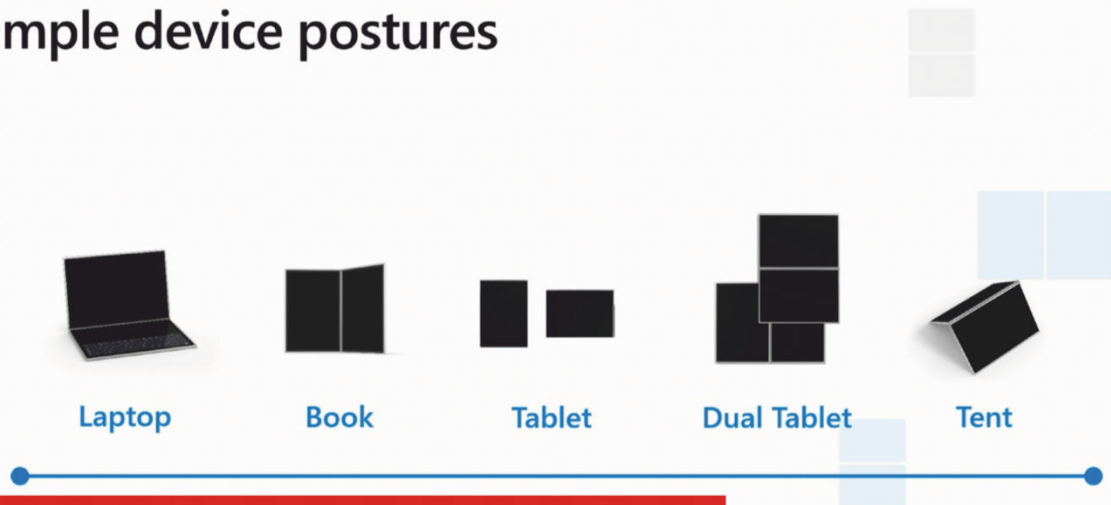
At a developer event in February, the company made a Windows 10X emulator available – though you'll need to assign a fairly powerful PC to the task, and dedicate it to the Windows Insider program. Microsoft revealed several intriguing characteristics of the new operating system as well, including lightning-fast updates, a special way of handling Win32 apps, and no apparent need for anti-malware apps.

Some have characterized Windows 10X as a new Windows 10 'experience', in much the same way a movie might be re-released in a special director's cut, with extras and in additional formats. But it's more than that, as it will interact with files and other applications differently than Windows 10 does. Microsoft's published enough separate documentation for us to start piecing together how Windows 10X will work. Here are a dozen intriguing features we've already learned about.

A simplified, prettier Windows shell

Windows 10X looks different. Most of what you expect about Windows still works – various inputs, drag and drop, the Clipboard, and more. But in Windows 10X, there's a small dock that incorporates elements of the traditional Windows taskbar, as well as the 'app drawer' on smartphones. The Windows Start launcher moves from the bottom left-hand corner of the screen toward the centre. The way app icons are aligned on the screen looks more like what you'd see on a traditional tablet or phone than the Windows desktop. Even apps are moved from one screen to the other via touch points on the bottom of the window, not the top.

Example device postures



The different hardware 'postures' for Microsoft's Windows 10X, specifically the Surface Neo

Windows 10's tiled Start interface? That's gone, too. Everything within Windows 10X looks simple and clean.

Windows 10X understands what the hardware is doing

Microsoft expended quite a lot of effort hammering home why dual-screen devices are cool, both from a developer and user perspective. Two displays – though separated by a physical hinge – offer a variety of ways of communicating information. But there's two separate aspects, including the hardware and the software.

Microsoft envisions five separate hardware modes: laptop, book, tablet, dual tablet, and tent. The three most interesting include tablet mode, where the rear display folds back out of sight and shuts off, to save on power and mistaken input. Tent mode, as with currently available 360-degree convertible laptops, is optimized for presentations. Last but not least, the Surface Neo's

keyboard flops up to cover part of the screen, creating what Microsoft calls...

The Wonder Bar: A Touch Bar that makes sense

When the Surface Neo's keyboard is attached to the device, a small strip of space is left uncovered. That's what Microsoft calls the Wonder Bar, a space for extra content, suggested emoticons or GIFs, or whatever.

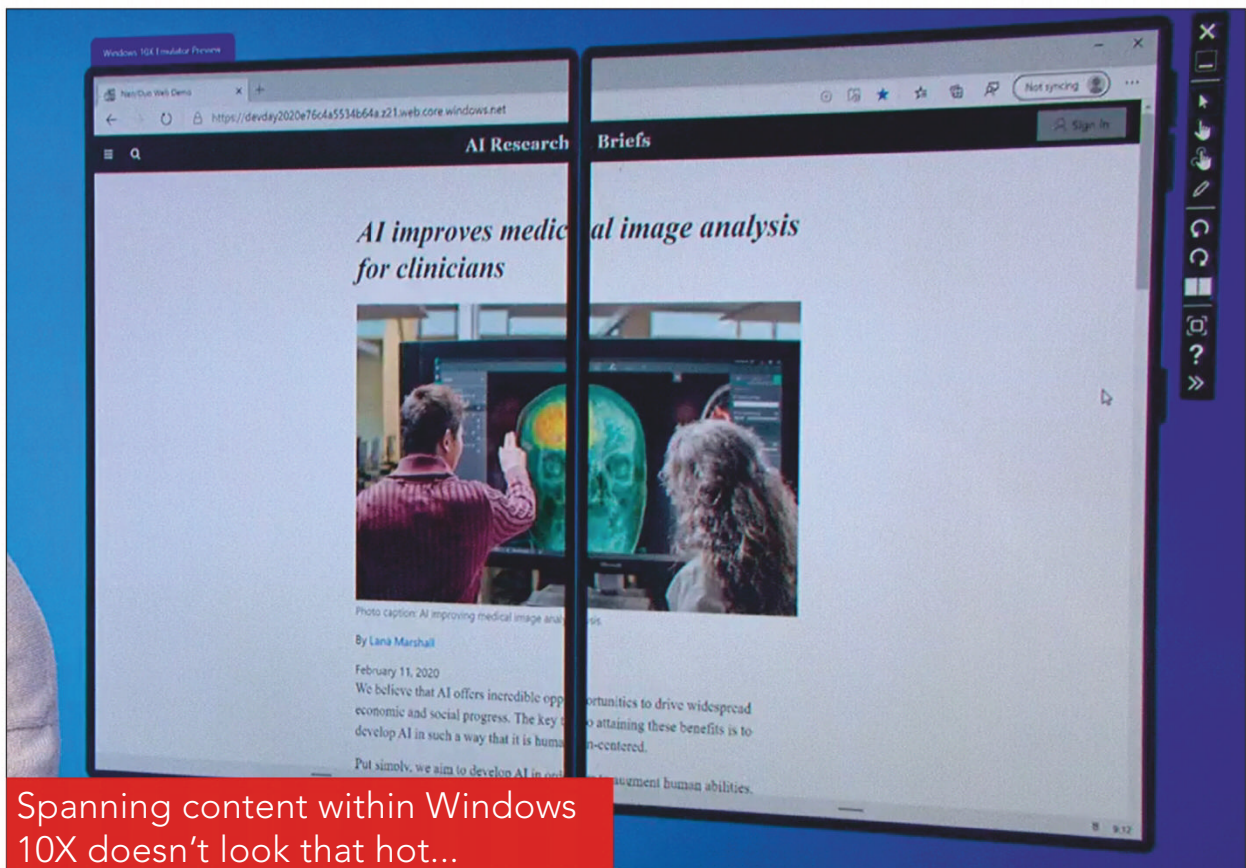
Looks like the MacBook Pro's Touch Bar, you might sniff. But the Wonder Bar is inarguably better: bigger, so it can show more, and it also does more. In this picture, posted during Microsoft's Windows 10X developer presentations, you can see Microsoft's keyboard suggestions – a fantastic use of the technology. Auto-completing text suggestions are an integral part of smartphones, but they feel useless in Windows. (Try them yourself in Settings > Devices > Typing > Show text suggestions as I type.) By placing



them right above the keyboard, you can quickly reach out and tap them, then return to typing.

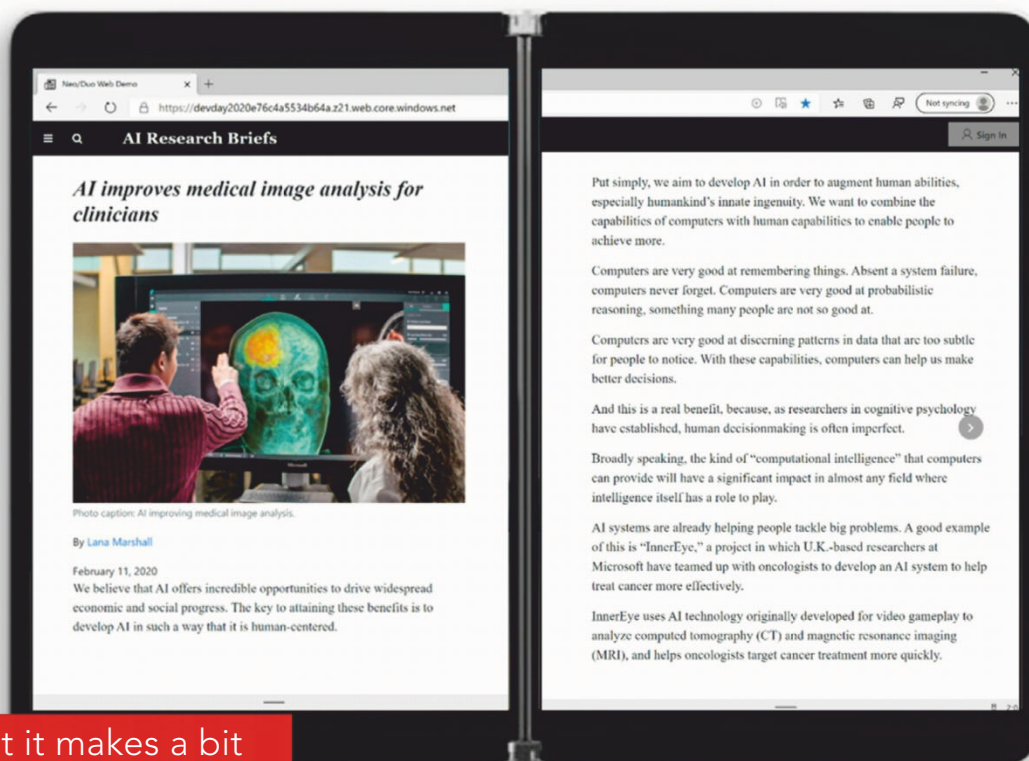
Smart software spreads content across screens

Anyone who's worked with multiple displays understands the benefits of seeing more information at any given time. Windows 10X does this in three ways: allowing apps to open in what's known as 'expansive workspaces', spanning apps across dual screens; 'focused screens', which puts separate apps on each individual screen, and 'connected apps', which puts separate apps on either screen but lets them talk with one another.



There already appear to be pluses and minuses to this approach. Spanning a web page across both screens – with a gap in the middle – looks a bit awkward when the gap splits a page vertically. But Microsoft's right in suggesting that if we're reading email on one pane, we might want to open a Calendar app in a second pane.

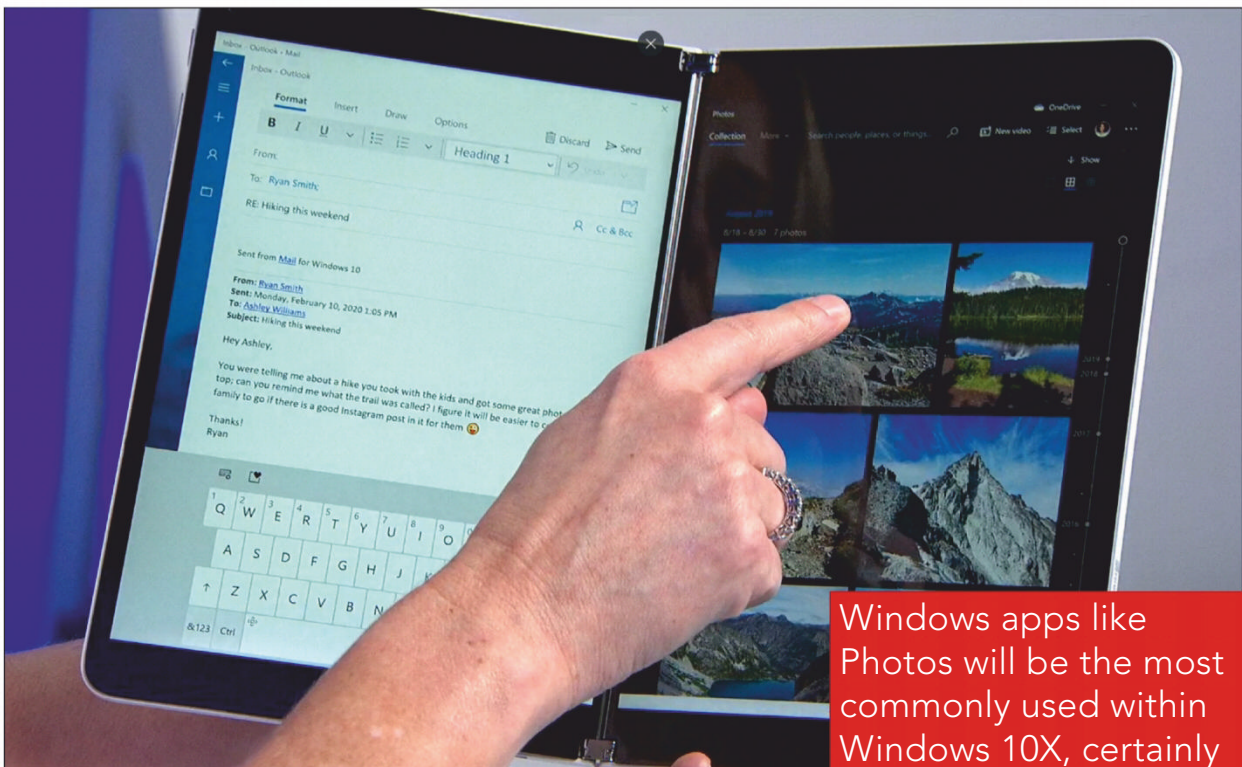
According to Kevin Gallo, corporate vice president of the Windows Developer Platform, apps will open in a single display by default. Searching for a restaurant in Edge, for example, will open the browser in one pane. Tapping a map of the area will open the Maps app in a second pane, while leaving the first open. This makes sense.



Windows 10X is read-only

The core Windows 10X operating system is designed in a locked-down mode, so that only trusted apps are able to run in the operating system. You've heard this before – that's the same model for Windows 10 S. (But wait! Legacy Win32 apps are supported, and we'll explain how in a bit.) What's different is that Windows 10X also runs signed code and apps with a 'good reputation', including those published in the MSIX container, widening the available apps beyond just the traditional UWP apps, such as Mail and Calendar.

That doesn't mean that apps will have to be downloaded from the Microsoft Store app, either. As long as the app is trusted, it can be downloaded from a website, USB key, or another location. That's a big change from Windows 10 S.

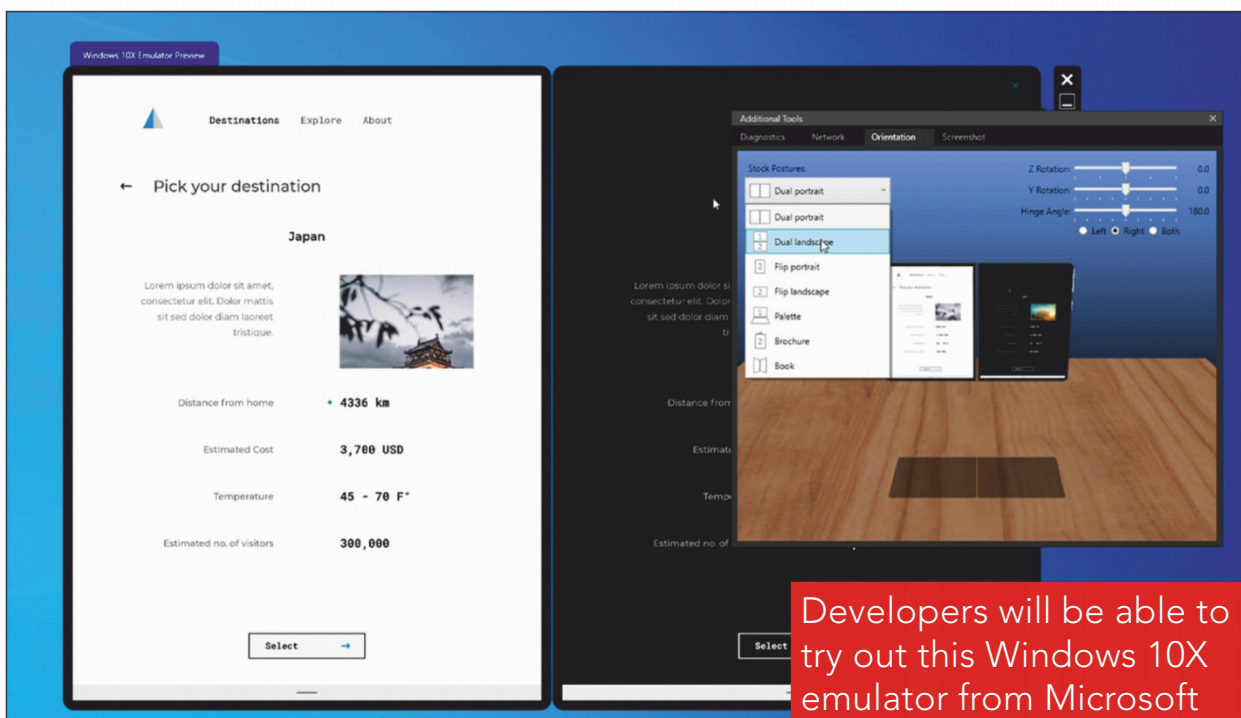


Windows 10X won't require anti-malware

As with Windows 10 S, Microsoft believes that relying on signed and trusted applications will remove the need for anti-malware applications, even possibly including Windows Defender. That means the performance overhead that antimalware requires can be reallocated to other areas within the operating system, Microsoft executives said.

Windows updates will take 90 seconds

According to Andrew Clinick, a Microsoft partner group program manager, Windows 10X won't require more than 90 seconds to update your PC. How? For one, they'll take place in the background. Clinick also said that Windows 10X will operate a bit differently than Windows 10, in that the operating system will be downloaded as a separate state, presumably as a



patched copy of the OS that will exist entirely separate from the unpatched OS. You'll apparently have one version of Windows 10X running in the foreground, another one downloading in the background, and the reboot will simply swap between the two.

App updates will be incremental

You'll see some improvements in app updates, too. John Vintzel, the program manager lead for Microsoft, said that one advantage of a new MSIX app packaging container will be that all of the app's resources will be contained within it, each with its own unique software hash. In fact, there will be three containers: native containers for UWP apps, which will offer the best performance as well as battery life; the MSIX containers, which will offer high compatibility with existing apps and a robust installation/uninstallation procedure; and the new Win32 container, which we'll discuss in a bit.

When a new app is downloaded, the hashes of each of the components will be compared against the update. If a particular component (say the app icon) is left unchanged, it won't be downloaded and updated, saving bandwidth. But even if a component is downloaded, it will be divided up into blocks, and only those blocks that have been changed will be downloaded. Even better, those blocks can be downloaded and then merged with the app later on, taking care of the process in the background.

It sounds like this same approach will be used to patch the Windows 10X OS, too. The secondary patched OS will be constructed from just what's new,

saving you from redownloading the entire operating system every time a patch is released.

Farewell, registry cleaners

The UWP apps within Windows 10X, incidentally, will only be able to access certain libraries. Photos would just be able to access your Photo library, for instance, just as UWP apps behave within Windows 10. "Apps can interact with the OS, but only via a clear set of APIs," Clinick said.

"No more registry fiddling to optimize the OS," Clinick added. "And my personal favourite, no more registry cleaners."

Say goodbye (again) to 'bit rot'

Microsoft promised this with Windows 10 S, and it's making the same pledge again with Windows 10X: Because the initial code and subsequent OS and app updates will be clean and tidy, you shouldn't see 'bit rot', the degradation of performance that often accompanies a PC over years of operation.

"We're going to have sustained performance, ensuring the performance you see on day one stays with you for the lifetime of the machine," Clinick added. "That's so important. Because last time I checked processes don't get slower, the more you use them."

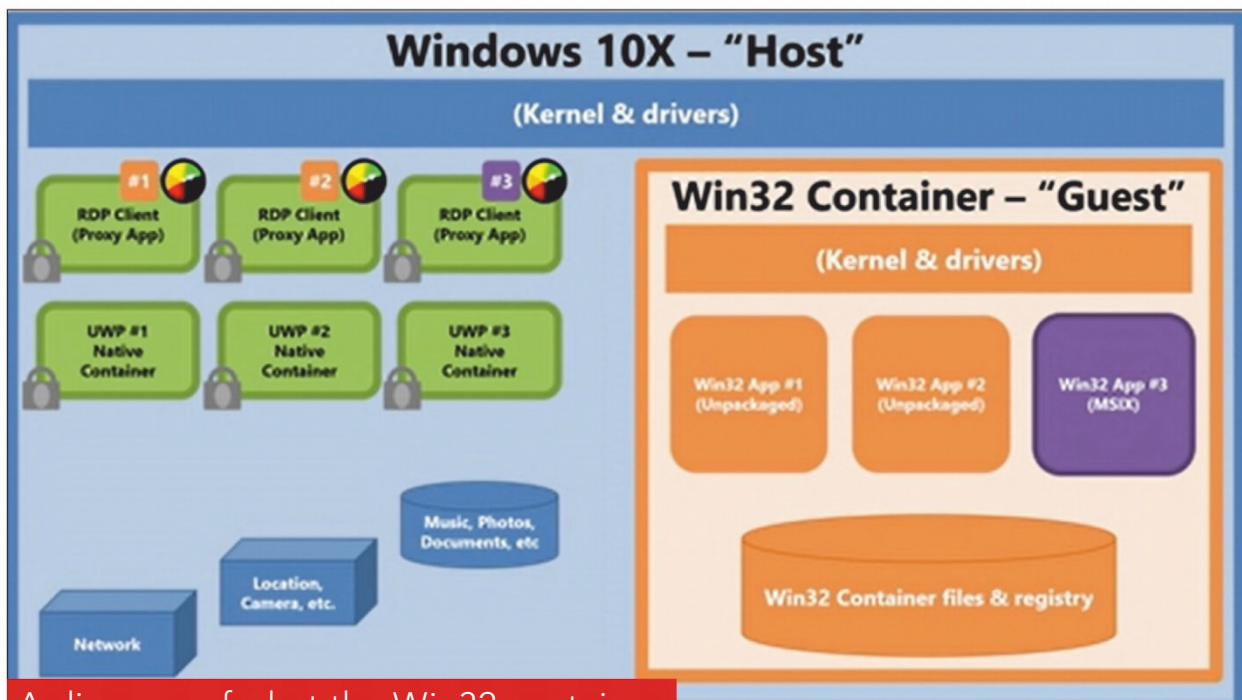
The Win32 Container: How legacy apps are supported in Windows 10X

How Windows 10X deals with legacy Win32 apps is one of the most fascinating parts of Windows 10X, and it builds upon a number of the other components we've

already mentioned. Basically, Windows 10X will support most legacy Win32 apps, and it will do so by stealing a few tricks from Microsoft's secret sauce: virtualization.

Every app within Windows 10X runs within its own container – intended to protect the OS from potential malware. But the Win32 Container exists separately, as a large vault of sorts for legacy Win32 code. (MSIX Containers will run inside the Win32 Container – yes, as a container insider a container, too.) Inside the Win32 Container runs all of the legacy Win32 apps that you may want to keep around: system utilities, old games, and the like. There's even a traditional Windows directory tree, and its own kernel, drivers, and registry.

The Win32 Container is essentially a virtual machine, though with higher integration, much lower latency, and



A diagram of what the Win32 container looks like inside the Windows 10X host

with access to more resources on the host Windows 10X than a VM has. Together, it all offers greater overall performance, according to Peter Torr, a principal program manager at Microsoft. Oh, and if there are no Win32 apps running? The whole thing shuts down. Even inactive Win32 apps are 'tombstoned', essentially left in a very low-power state to preserve battery.

But opening the Win32 app within Windows 10X doesn't actually launch it directly. Instead, what Windows 10X does is create 'proxy' apps within the Windows 10X host operating system – essentially, using a Remote Desktop-like interface to access the secured Win32 app within the Win32 Container. Microsoft promises you'll have near-native performance of these apps, but some sort of slowdown would seem likely.

Privacy within Win32 apps

There will be a few bumps along the way. While all 'typical' PC hardware – mice, keyboards, pens, touchscreen, printers, networking devices – should work as expected within Windows 10X, there will be limitations on "non-standard hardware" and "app-installed drivers", Microsoft says. Microsoft's also putting some broad limitations on what it's calling "privacy-sensitive hardware," such as the camera and microphone. In this case, all Win32 apps will have access to the mic, or none will; there are no per-app permissions, Torr explained.

Torr listed other limitations to Win32 apps in Windows 10X: No system tray applets will be allowed, and you won't be able to use File Explorer add-ins or namespace extensions, for example. If there's an app or

Shell experiences in the Win32 Container.

- **Windows 10X has a new, simplified shell.**
 - Most of what you expect from Windows just works.
 - Start, windowing, input, graphics, drag & drop, clipboard...
- **Some Desktop shell features aren't present in Windows 10X.**
 - System tray applets.
 - File Explorer add-ins, namespace extensions, etc.
 - Mouse, keyboard, or window hooks.
- **The APIs / Registry entries still exist, they simply no-op on 10X.**

Some of the limitations of Win32 apps within Windows 10X

utility that you interact with via the system tray, it'll have to move elsewhere within Windows 10.

There's a lot here already, and it's only February. Expect to hear more about Windows 10X as 2020 progresses, including at Microsoft's Build 2020 conference in late May.



Credit: Getty Images/onurdongel

How to use your TV as a computer monitor

Turning your king-size TV into a king-size PC display is easier than you think. **SARAH JACOBSSON PUREWAL** reports

You're not the first person who's wondered what it would be like to have a giant desktop monitor. Think of all the multitasking and immersive gaming you could manage if you had a 50- or 60in monitor instead of a standard 24in monitor. But you've probably noticed that as monitors get bigger, they also tend to get prohibitively expensive.

You've probably already got a big screen in your house, though – a TV. At the end of the day, isn't an HDTV just a giant, living-room-oriented computer monitor? Not exactly. While you can use a TV as a computer monitor in most cases, that doesn't mean it's the best option. In fact, it's likely less attractive, convenient, and usable than you think (not to mention, probably not that cheap). There's a reason dirt-cheap 32in HDTVs aren't flying off the shelves to be used as budget-friendly jumbo screens.

You definitely can use an HDTV as your PC's display, though. Here's everything you need to know about how to set up a TV as a computer monitor – and why you might not want to.

Will it even work?

The short answer: Yes. You may need a special cable, depending on your PC's outputs and your HDTV's inputs, and you'll need to check a couple of settings, but you shouldn't have too much trouble hooking most modern PCs up to most modern HDTVs.

Modern HDTVs have HDMI outputs. Some older HDTVs have DVI inputs, and some even have VGA inputs specifically designated for 'PC use'. If your graphics card has an HDMI output, you're good to go: just use an HDMI cable to connect your PC to your HDMI.

If you're using an older graphics card or motherboard that only has a DVI output, you can snag a cheap DVI-to-HDMI cable and plug it into your HDTV's HDMI output. Although some older HDTVs and some older computers only have VGA inputs/outputs,

they aren't not an ideal choice. VGA's an analog signal that will give you a far fuzzier, lower-resolution image than you'll get with an HDMI or DVI cord.

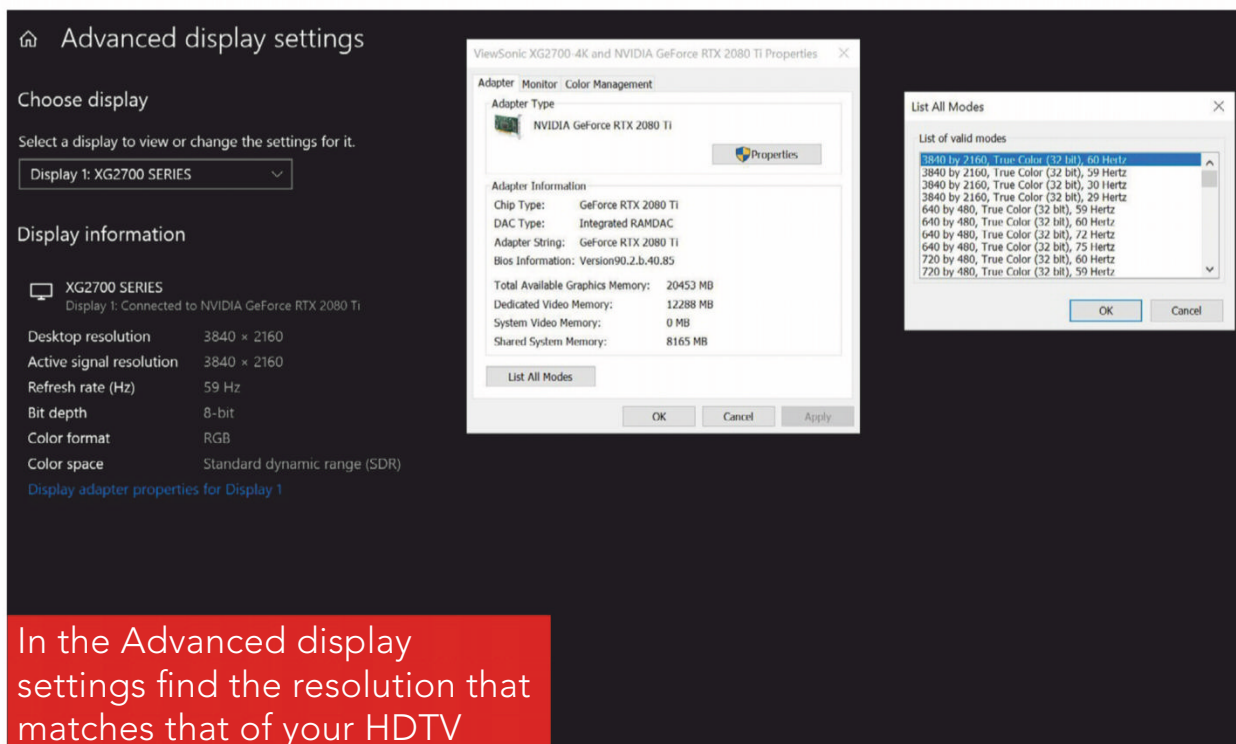
If you want to use your HDTV as a second or third monitor, you may need to use a different port, such as your graphics card's DisplayPort output. In this case, you'll need to use a different cable (DisplayPort-to-HDMI). The main advantage to using the DisplayPort output instead of DVI or VGA is that HDMI and DisplayPort carry both video and audio signals. A DVI-to-HDMI cable can transmit both video and audio if your graphics card supports HDMI audio via DVI – unlikely if it doesn't have any HDMI ports – while VGA only transmits video. If you use DVI or VGA, you will most likely need to connect your PC's audio up to the HDTV separately, or use external speakers or a headset.

Bottom line? Try to stick to HDMI if or DisplayPort-to-HDMI connections if it's possible. .

Getting your PC ready

You'll also need to determine whether your graphics card (or your PC's integrated graphics) is capable of outputting at the resolution of your HDTV. To do this, you will first need to find the resolution of your HDTV by consulting the manufacturer's manual. Some HDTVs have non-standard resolutions; it's not a given that your HDTV will be supported. Most stick to standard 720p, 1080p, or 4K resolutions, however. Next, find the maximum resolution your graphics card/integrated graphics supports.

Open the Windows 10 Start menu and head to Settings > System > Display > Advanced display



settings > Display adapter properties for Display 1. In the window that pops up, click List All Modes. Find the resolution that matches that of your HDTV and select it. Will it look good? Maybe. It depends on how you're using it.

HDTV features to keep in mind

If you're turning your HDTV into a PC-backed multimedia powerhouse, and you plan on using it primarily as a television and streaming hub – for example, a screen you'll continue to view from several feet away – it will probably look fine. But if you're trying to stick a 60in HDTV on a desk, you're more likely to end up with headaches and eye strain.

There are a few different factors to keep in mind if you want to use an HDTV as a computer monitor.

Pixel density

Pixel density, or the number of pixels packed into one square inch of screen (measured in pixels per inch or ppi), is the most important factor to consider. A 15.6in laptop screen with a 1,920x1,080 resolution has a pixel density of 141.21ppi, while a 32in HDTV screen with the same resolution has a significantly lower pixel density of 68.84ppi. The lower the pixel density, the less clear and detailed the image becomes.

But the importance of pixel density decreases with viewing distance. The further you sit from a screen, the lower the pixel density need to be for you to have a comfortable viewing experience. You won't have any problems looking at a 15.6in/141.21ppi screen from two feet away, but you will find it much harder to view a 32in/68.84ppi screen from the same distance. This is why a 'Retina' screen on the iPhone has a pixel density of 326ppi, but a 'Retina' screen on the MacBook Pro has a pixel density of just 226ppi.

A normal user sits between two and three feet away from a desktop monitor. To comfortably view a monitor at this distance, you should aim for 80ppi or higher. This means that for 1,920x1,080 (1080p) resolution, your screen should be no larger than 27.5 inches diagonally, and for 4K sets, you'll want to max out at 55 inches, like the TCL DP628 4K UHD TV (£479 from fave.co/3by4w2J). We reviewed it, and it's solid.

Important: '4K' is not a market standard. A 4K HDTV can mean 4x 720p (3,840x2,160 resolution) or 4x 1080p (4,096x2,160 resolution). Most models use 3,840x2,160, but you should check the exact specs of your model to determine pixel density.

TCL DP628 4K UHD TV



Input lag

Input lag is the delay between movement you make on your input device (in this case, a mouse and keyboard) and what displays on your screen. While most computer monitors prioritize minimal lag times, HDTVs generally do not – they prioritize (laggy) video processing instead. These extra milliseconds may not seem like they matter, but they will make a massive difference if you're trying to do something like competitive online gaming.

DisplayLag maintains a good database of input lag times, sortable by display type. An input lag of less than 30 milliseconds is considered good for an HDTV

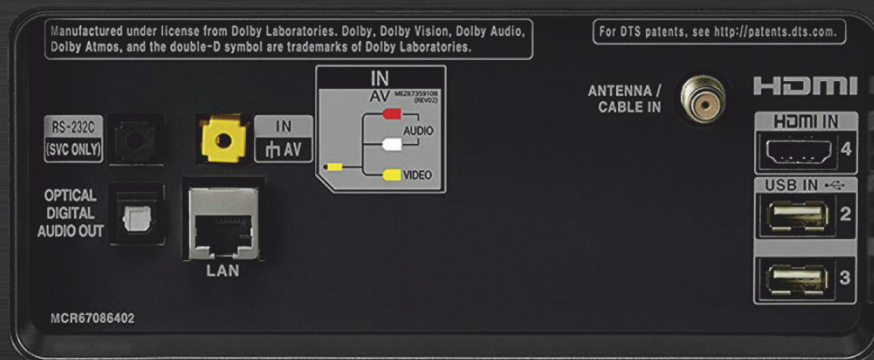
if you're using it as an HDTV. For a computer monitor, you'll want to aim for less than 20 milliseconds, and the lower you can go, the better.

Response time

Often confused with input lag, response time describes how long it takes for a display's pixels to switch colours between scenes. HDTVs and computer monitors can have very different response times. HDTVs tend to prioritize richer colours, higher contrast, and wider viewing angles – all of which lend to a longer response time. Computer monitors tend to drop some of the image processing and viewing angles for faster response times. If you use a display with a slower response time, you may see 'ghosting' in fast-paced video and gaming sequences.

Some HDTVs have a 'game mode' setting, which cuts some of the image processing to improve both

Also pay attention to the type and number of ports. This is only one of two port areas on an LG TV. Many TVs offer ports nearer the side as well for the sake of easy access



input lag and response time. If you plan to play PC games on your TV, definitely dig around in your HDTV's options to see if it has this feature.

Refresh rate

Another factor that may affect performance is a display's refresh rate. Refresh rate is the number of times a display 'refreshes', or re-draws, its image each second. Most modern displays have a refresh rate of 60Hz, which means they refresh their image 60 times per second. But you've probably also seen higher-end gaming monitors and HDTVs with higher advertised refresh rates – 120Hz, 144Hz, or even 240Hz. This can be misleading, however, because a computer monitor with a 120Hz refresh rate may not be the same as an HDTV with a 120Hz refresh rate.

The reason for this is because the content people watch on a television is produced at either 24-, 30-, or 60fps. The content people view on a computer monitor can be very different – many games can output frame rates higher than 60fps if you have a powerful enough graphics card.

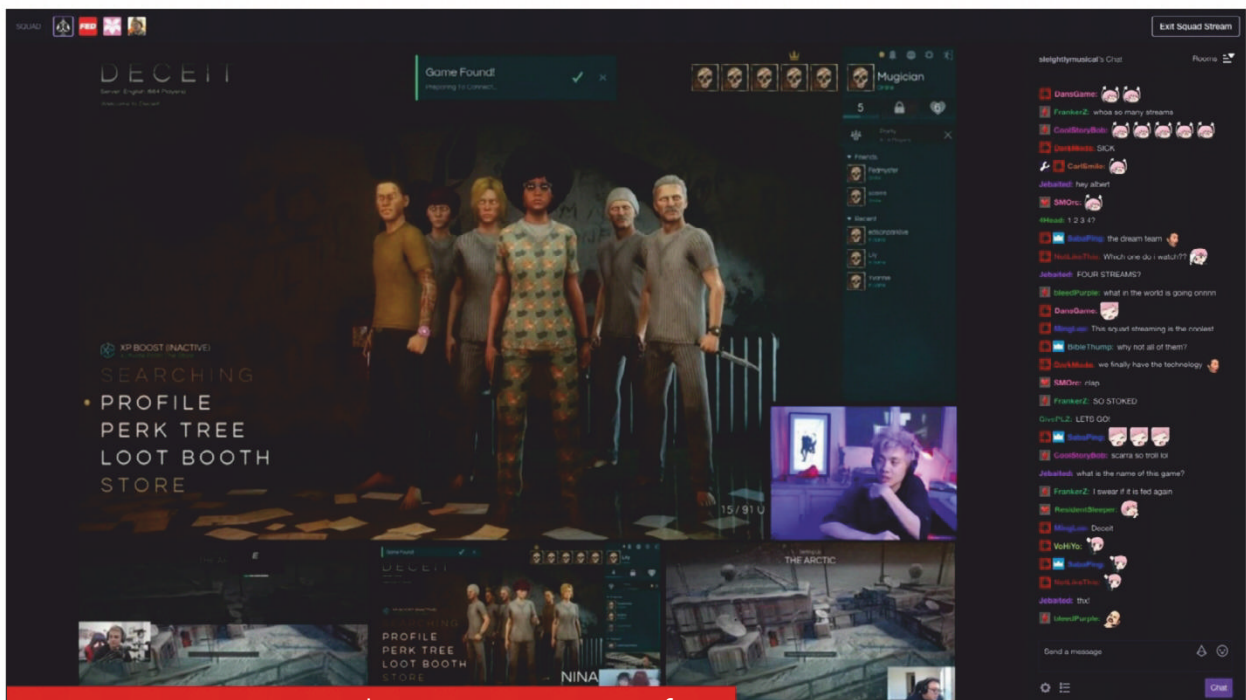
An HDTV with a high advertised refresh rate may use post-processing technology to achieve that rate, such as by creating additional frames to upscale content, or by adding black frames between each frame to prevent image blur. The good news is that this probably won't make a difference if you're not playing PC games at very fast frame rates. But if you have a PC designed for the best possible gaming experience, hooking up an HDTV instead of a computer monitor likely means that you're not getting the most out of your machine.

Is it worth it?

There's no harm trying to connect your computer to a TV you already own to see if it works for you. Go for it.

Our advice varies if you're shopping though. If you're looking to get the best bang for your buck, an HDTV isn't necessarily going to save you money over a monitor. In fact, if you're purchasing a new display, I recommend sticking with the tried-and-true computer monitor. For one thing, smaller, cheaper HDTVs are typically 720p resolution, not 1080p, while similarly priced monitors will almost always be 1080p. So if you're looking for something under 27 inches, an HDTV will probably be more expensive and lower-resolution.

These lower-priced 1080p monitors often support AMD's FreeSync adaptive sync technology as well,



An HDTV as a secondary monitor is perfect for streaming Twitch, watching Netflix, or keeping an eye on Twitter in real time

which can help your games look buttery smooth. You won't find that in a cheap TV.

If you're looking for something larger than 27 inches, remember that pixel density decreases significantly with every few inches you gain, and there's a reason HDTV-makers suggest sitting several feet away from their displays. If you need a display that will multitask as an up-close work/email display as well as a movie/entertainment display, you'll want something with a high enough pixel density that text won't be a pain to read – and even with a high pixel density, a large display may still cause eye and neck strain if you sit too close to it.

There is an ideal situation in which the HDTV-as-monitor shines, though.

If you want to add an extra display to a single- or multi-display setup for entertainment – say, so you can watch Netflix or Twitter while you write articles, or so you can play Skyrim on a 60in screen – then an HDTV can be a very capable (and cool) monitor replacement. Bonus points if you happen to have an extra HDTV lying around, or if you can pick one up for dirt cheap.